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FLIP RASTER PROCESSING SOFTWARE SYSTEM

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Final Technical Report
March 1977

FLIP RASTER PROCESSING SOFTWARE SYSTEM

Synectics Corporation

ROME AIR DEVELOPMENT CENTER
AIR FORCE SYSTEMS COMMAND
GRIFFISS AIR FORCE BASE, NEW YORK 13441

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This report documents work performed for the Defense Mapping Agency Aerospace Center/Aeronautical Department. The effort consisted of configuring a stand-alone system for the production of Flight Information Publication (FLIP) graphics.

The digitizing/editing system was a standard Bendix system 101. A special

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interface was designed and fabricated to allow the Bendix 101 control (Data General, Nova 1220) to also control a DACOM Model K-661A raster plotter. The software written performed the task of converting lineally digitized files to raster for plotting on the DACOM. This software has the capability to create line-weights from line center files, perform area fills, generate screen fills, and produce alphanumerics in the correct style and size.

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SECTION 1

INTRODUCTION

1.1 General

This report is the final technical report for the Flight Information Publications (FLIP) Raster S/W Processing System. The information herein is in fulfillment of the obligations set forth in Contract Number F30602-76-C-0059. Companion documents which provide very detailed technical information are as follows:

- √ Bendix Interactive Drafting System Operator's Manual
- √ Bendix Interactive Drafting System Programmer's Manual
- √ Test Plans and Procedures for the FLIP Raster S/W Processing System
- √ FLIP Raster S/W Processing System Operator's Manual
- √ FLIP Raster S/W Processing System Programmer's Manual
- √ K661A/NOVA Interface Maintenance Manual

1.2 Background

The current procedures employed at the Defense Mapping Agency Aerospace Center (DMAAC) for the preparation, production and revision of FLIP graphics are largely dependent upon manual techniques. The volume of FLIP graphics which must be maintained, their associated short term revision cycle and their diagrammatic nature are characteristics which make them uniquely suited for cost effective production on a digital system. DMAAC has conceptualized a distributed processing approach to the production of graphic FLIP products. The graphic system developed and implemented under this effort is an integral part of that total concept. RADC procured a Bendix System 100/101 (Interactive Drafting System) and a Dacom Model K661A plotter which was made available to Synectics under this effort to serve as basic equipment elements of the FLIP graphic production station.

1.3 Objective

The need and utility for a digital graphic production system is fairly obvious to anyone who has worked in a mapping/charting production facility and observed that updating and re-publication of a graphic product often requires nearly as many man hours as did the original cycle. The ability to create, store, modify and manipulate these digital graphic files interactively through the use of automated techniques will eliminate innumerable hours of redundant human effort. Therefore, the objective of this effort was to develop and implement a special purpose digital graphic system at DMAAC to support the preparation, production and revision of FLIP Graphics. In order to accomplish this objective Synectics has integrated existing standard equipments through special interfaces coupled with the modification and enhancement of existing control and applications computer software. This approach necessitated an indepth functional analysis and design phase at the outset of the effort. This analysis and design effort was guided by and disciplined to follow some method for logical accomplishment. Figure No. 1-1 is the initial work plan developed to guide the data collection, analysis, design, implementation and testing of the FLIP Raster Processing S/W System.

1.4 Functional Analysis and Design

The analysis and design effort with its inclusive tasks was the nucleus of activity to be performed. This activity was guided by the work plan as outlined in Figure No. 1-1. The requirements as outlined in the Statement of Work (SOW) titled "FLIP Raster Processing S/W System", dated 28 March 1975 was divided into five major tasks.

- ✓ Hardware Acquisition and Integration
- ✓ Develop Lineal to Raster Conversion Program
- ✓ Analyze Bendix System 101 and Determine Mods Required
- ✓ FLIP Symbol Analysis and Library Generation
- ✓ Develop DACOM Plotter Controller Programs

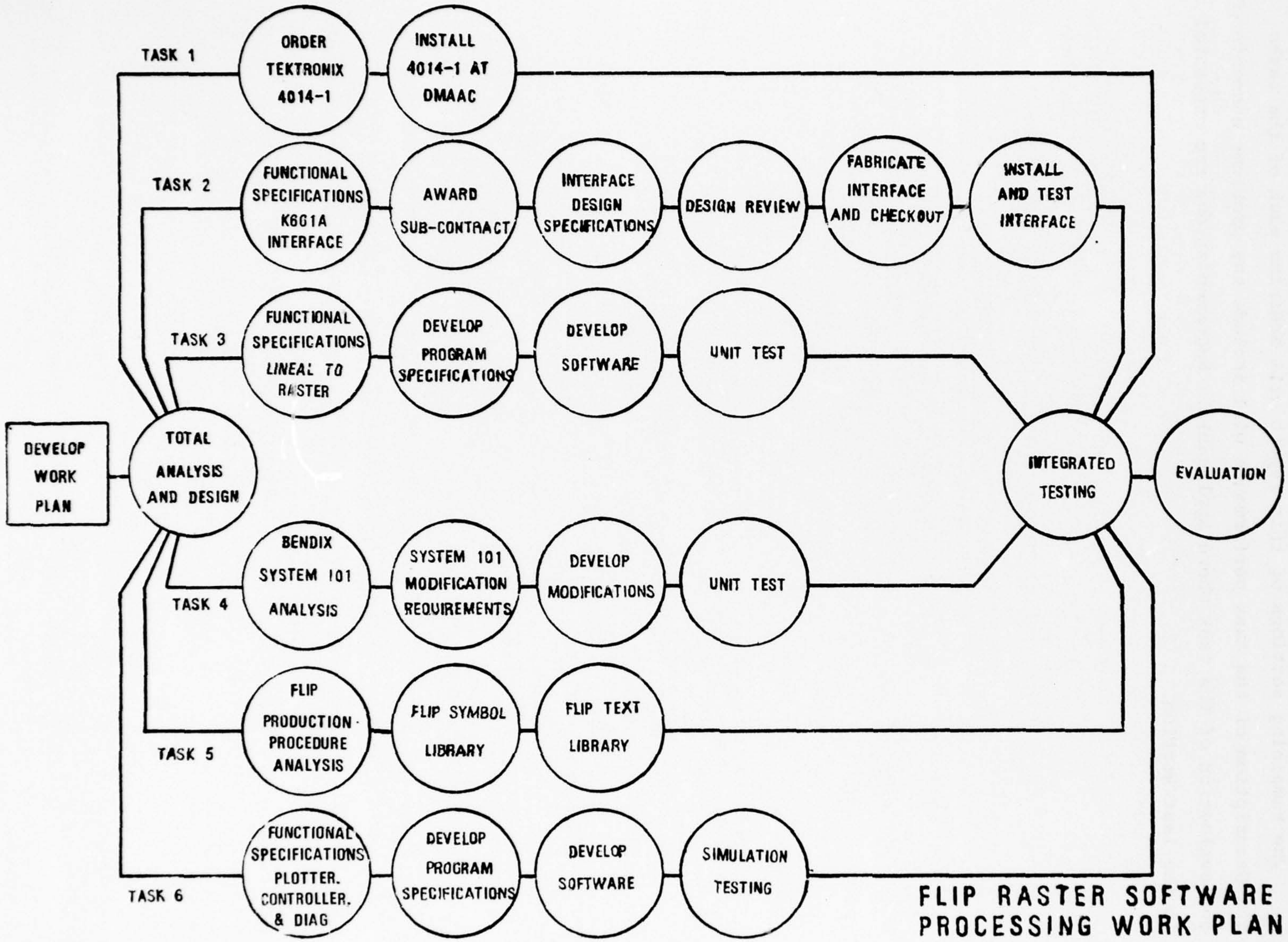

TASK 1
ORDER TEKTRONIX 4014-1
INSTALL 4014-1 AT DMAAC
TASK 2
FUNCTIONAL SPECIFICATIONS K661A INTERFACE
AWARD SUB-CONTRACT
INTERFACE DESIGN SPECIFICATIONS
DESIGN REVIEW
FABRICATE INTERFACE AND CHECKOUT
INSTALL AND TEST INTERFACE
TASK 3
FUNCTIONAL SPECIFICATIONS LINEAL TO RASTER
DEVELOP PROGRAM SPECIFICATIONS
DEVELOP SOFTWARE
UNIT TEST
DEVELOP WORK PLAN
TOTAL ANALYSIS AND DESIGN
INTEGRATED TESTING
EVALUATION
TASK 4
BENDIX SYSTEM 101 ANALYSIS
SYSTEM 101 MODIFICATION REQUIREMENTS
DEVELOP MODIFICATIONS
UNIT TEST
TASK 5
FLIP PRODUCTION PROCEDURE ANALYSIS
FLIP SYMBOL LIBRARY
FLIP TEXT LIBRARY
TASK 6
FUNCTIONAL SPECIFICATIONS PLOTTER. CONTROLLER. & DIAG
DEVELOP PROGRAM SPECIFICATIONS
DEVELOP SOFTWARE
SIMULATION TESTING
FLIP RASTER SOFTWARE PROCESSING WORK PLAN

Figure No. 1-1

The remaining sections of this report will describe each of the tasks. The description of the task performance will include any problems encountered and evaluation of the task where applicable. Recommendations are presented in the last section.

SECTION 2

HARDWARE ACQUISITION AND INTEGRATION

2.1 General

The Bendix System 101 supplied to the contractor resides at DMAAC, St. Louis, MO. This hardware configuration served as the nucleus of the hardware to which an improved display capability and government furnished plotter was interfaced. The original hardware consisted of the following components:

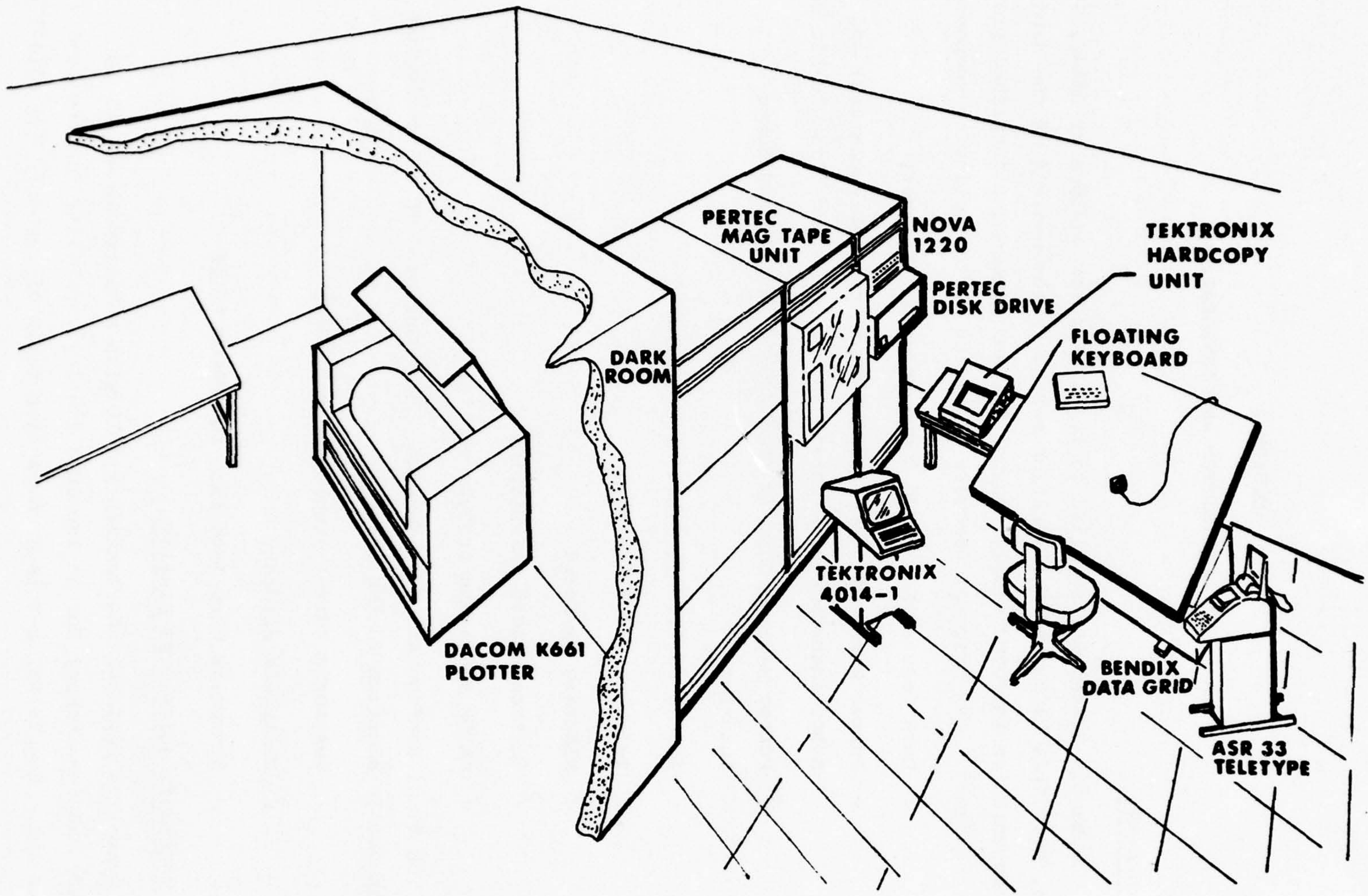
- ✓ Data General Nova 1220 Computer with 24K Memory
- ✓ Pertec Disk Unit (one fixed and one removable platter) and Xebec interface with total capacity of 2.5 million 16-bit words
- ✓ Pertec Magtape Unit (9 Track/800Bpi/25ips) and Xebec interface
- ✓ Bendix Digitizing Table with Cursor
- ✓ Teletype Model ASR33
- ✓ Floating Keyboard
- ✓ Tektronix 4010 CRT Display
- ✓ DACOM K661A Raster-Type Plotter

The final configuration (Figure No. 2-1) consisted of the following components in addition to the above:

- ✓ Tektronix 4014-1 (replacing the 4010)
- ✓ Tektronix Hardcopy Unit
- ✓ Synectics Corp Interface for DACOM K661A

2.2 Tektronix 4014-1 CRT Display

Synectics replaced the Tektronix 4010 with a Tektronix 4014-1 to satisfy the requirement for an improved display capability for the Bendix System 101. Figure No. 2-2 is a comparison table of the 4010 and 4014-1.



FLIP PROCESSING SYSTEM CONFIGURATION

Figure No. 2-1

TERMINAL CHARACTERISTIC	TEKTRONIX 4010	TEKTRONIX 4014
DISPLAY MEDIUM	DIRECT VIEW STORAGE CRT	DIRECT VIEW STORAGE CRT
SCREEN SIZE	7.5 INCHES WIDE BY 5.6 INCHES HIGH	15 INCHES WIDE BY 11 INCHES HIGH
ALPHANUMERIC MODE	ONE FORMAT 1) 74 CHARACTERS PER LINE, 35 LINES PER DISPLAY	FOUR FORMATS 1) 74 CHARACTERS PER LINE, 35 LINES PER DISPLAY 2) 81 CHARACTERS PER LINE, 38 LINES PER DISPLAY 3) 121 CHARACTERS PER LINE, 58 LINES PER DISPLAY 4) 133 CHARACTERS PER LINE, 64 LINES PER DISPLAY
ALPHANUMERIC CURSOR	5 X 7 DOT MATRIX PULSATING CURSOR	7 X 9 DOT MATRIX PULSATING CURSOR
CHARACTER SET	TTY ASCII CODE SET (63 CHARACTERS)	FULL ASCII SET (94 CHARACTERS)
VECTOR MODE	1024(X) BY 1024(Y) ADDRESSABLE POINTS 1024(X) BY 780(Y) VIEWABLE POINTS	1024(X) BY 1024(Y) ADDRESSABLE POINTS 1024(X) BY 780(Y) VIEWABLE POINTS
ENHANCED GRAPHIC MODE	NONE	4096(X) BY 4096(Y) ADDRESSABLE POINTS 4096(X) BY 3120(Y) ADDRESSABLE POINTS
GRAPHIC INPUT MODE	THUMBWHEEL CONTROLLED CROSSHAIR 3 THRU 1023 HORIZONTALLY AND 0 THRU 780 VERTICALLY ADDRESSABLE POINTS	THUMBWHEEL CONTROLLED CROSSHAIR CURSOR 3 THRU 1024 HORIZONTALLY AND Ø 780 VERTICALLY ADDRESSABLE POINTS

TEKTRONIX 4010/4014 COMPARISON CHART

Figure No. 2-2

The 4014-1 includes the enhanced graphics module which will provide several advantages over the standard 4014-1 such as:

- √ Rapid point plotting (30X faster)
- √ More addressable points
- √ Variable vector intensities
- √ Improved cursor control

In addition, the Tektronix 4014-1 has a hardcopy interface built into it to accommodate the Tektronix Hardcopy Unit. This unit provides permanent, dry copies of any information displayed on the terminal screen and it has a stacking tray to hold the copies.

2.2.1 CRT Display Mod Kit

The Tektronix 4014-1 installed at DMAAC utilizes the interface card from the 4010 which it replaced. The high speed interface which was purchased with the 4014-1, could not be installed due to the conditions specified herein.

This interface is in the form of a kit and requires minor mods to existing hardware. It was designed for a Data General (DG) 4077 I/O interface card. The mod kit makes the 4077 compatible with their interface by disconnecting the DG TTY clock and using their own clock with reconditioning of some signals. Having no hardware documentation concerning the Bendix System 1Ø1 TTY interface, it was assumed that no special configuration existed. This proved to be false. When the mod kit was delivered to DMAAC, Synectics prepared to perform the hardware modification as normal. At this time it was discovered that Bendix had not used the standard DG 4077 I/O interface card. Instead, they fabricated their own dual communications interface. The mod kit could not be directly applied to Bendix interface since it is physically different from the DG 4077.

2.2.2 CRT Display Software

The Bendix System 1Ø1 required no software modification to drive the Tektronix 4014-1. The displays being generated on the new screen are more easily viewed. The 4010 screen viewing could be compared to watching a nine (9) inch diagonal television while the 4014 screen viewing could be compared to watching a nineteen (19) inch diagonal television.

The Bendix System 1Ø1 has the capability to drive the enhanced graphic module option, but the version supplied to DMAAC has not been mapped to do so. The change required to allow this function consists of setting a program cell to the value one (1). This can be resolved in one of two ways. The appropriate program could be changed to reflect the above, it can then be recompiled and reloaded into its appropriate overlay. The other method would require the knowledge of the memory location of the program cell (derived from a load map and assembly listing) which could be changed at run-time with the "MODIFY" command.

The above mods are inherently trivial when the appropriate documentation is available. This is not the case for this effort. Generation of the revised overlay would best be done by Bendix when a new system version is procured. It seems that much of the software/hardware system facts/knowledge is stored not in technical reports but in the system designer/implementer's brain.

The second alternative was selected as the most expedient way to achieve the change. Bendix was requested to supply the program cell memory location value. The conclusion from the query was that they could and would supply the information in the near future and the mod would not result in a great visual change of the display.

2.3 DACOM K661A Plotter

The DACOM K661A Plotter was provided by the government to Synectics for system integration. The basic elements of the plotter are a rotating drum and an optical carriage. The drum is eight (8) inches in diameter and twenty-

four inches long. It is rotated by an induction motor at approximately 3600 RPM. Attached to the drum is an optical shaft encoder which has two outputs; a once per revolution zero pulse and a 1000 elements per revolution clock. The optical carriage has a glow modulator tube used to expose the photographic film. The effective exposure spot size is set by an aperture. The carriage has an aperture turret which enables any of the five different apertures. The optical carriage is traversed along the drum by a stepper motor, with 4800 steps required to move the carriage one (1) inch.

2.3.1 DACOM K661A Plotter Interface

The DACOM K661A has been interfaced to a digital computer for the first time under this effort. Synectics had Mr. Mark Williams of XEBEC Corporation under subcontract to accomplish the task of designing, fabricating and integrating the DACOM K661A Plotter Interface. The plotter is controlled and monitored by the NOVA computer by loading and reading registers of the interface card.

2.3.1.1 Command Register

The command register is loaded by the user program to control several plotter functions. These functions include the following:

- ✓ DRUM RUN
- ✓ DRUM STOP
- ✓ PLOT SELECT
- ✓ STEP SELECT
- ✓ VIDEO DATA MODE SELECT
- ✓ APERTURE SIZE SELECT
- ✓ VIDEO RESOLUTION SELECT

2.3.1.2 Status Register

The user program may obtain status of the operation in progress by reading the status register. Status indicators are provided for each of the following:

- ✓ DATA LATE
- ✓ FILM LOADED
- ✓ DRUM UP TO SPEED

2.3.1.3 Word Count Register

The Word Count Register is loaded by the user program to control the number of data words to be output to the interface or the number of carriage steps to be traversed.

2.3.1.4 Memory Address Register

The Memory Address Register is loaded by the program with the starting address in NOVA memory of the data buffer.

2.3.2. DACOM K661A Plotter Software

The DACOM K661A Plotter is controlled by the plotter controller (KPLOT). The interface can be maintained using the plotter diagnostic (*KDIAG*). *These* software modules are discussed in Section 6.

SECTION 3

LINEAL TO RASTER CONVERSION

PROGRAM DEVELOPMENT

3.1 General

Before developing the Lineal To Raster Conversion (LRC) Module, analysis of the system software and the data acquisition (Bendix System 1Ø1) system had to be made. The latter is described in Section 4. For this discussion, it is sufficient to note that the data acquired via the digitizing system contains enough information (after some modifications) to be a viable data source for the LRC Module. This section will address itself to the system software/hardware and the LRC Module implementation under that system.

3.2 System Software/Hardware

The Bendix System 1Ø1 runs under a modified version of the Xebec Disk Operating System (XDOS) Version 1 known as the Bendix Disk Operating System (BDOS). The modifications are pertinent to the execution of the System 1Ø1. The LRC module executes as a stand alone entity (as opposed to background/foreground). The modifications to XDOS are not readily available in any documented form.

3.2.1 BDOS

BDOS is a continuously running supervisory program that controls most file transfers to and from random or non-radom access devices. A variety of files can be defined, loaded, overlayed, listed, edited and used as inputs to programs. Some of the features of BDOS are as follows:

- √ Device independence when device driver installed
- √ The system dynamically allocates storage on the disk without operator intervention
- √ Complete program overlay with capability to have nested sub-routines called from the disk.

✓ The system allows the user's programs to use interupts (BDOS does not use interrupts itself). This allows the user to use BDOS with certain devices, such as the DACOM K661A Plotter, without over-riding BDOS code.

✓ Basic Disk System Monitor with four file slots requires only 3K-16 bit words.

✓ Executive Commands allow debug and editing capability for user programs.

✓ System operates with various peripheral devices if the device driver is implemented.

3.2.1.1 BDOS Hardware Configuration

The basic BDOS hardware configuration consists of three functions. The Operators Console; The Computer Processing Unit; and the Moving Head Disk System.

The Operators Console is a Teletype Model 33ASR with a manual keyboard; 10 characters per second printer, paper tape punch, and paper tape reader.

The Computer Processing Unit for this BDOS package is the Data General Nova 1220

The Moving Head Disk System is Xebec's XMD5000 Series.

In addition to the basic hardware, a Magnetic Tape Unit and a CRT display has been added. The magtape unit is a Pertec unit (9 Track/800BPI/25 IPS) with Xebec Interface and the CRT display is a Tektronix 4014-1.

3.2.1.2 BDOS Software Configuration

The basic BDOS software requires 3K, 16 bit words in the Nova 1220. This program which includes four (4) file slots is the Disk System Monitor (DSM) and resides in memory at all times. The file slots are actually tables within the DSM that contains information regarding the position and status of all opened files. The basic BDOS provides for a maximum of four simultaneously open files. The basic BDOS software is device independent for the basic set of devices.

The addition of the magtape unit requires the magtape device driver. This module is not part of the DSM as installed at DMAAC. The appropriate programs were made available to the user when the Bendix Software Package was procured (in addition to the System 101). Note that the magtape driver software must be loaded along with the user programs as any other user subroutine.

3.2.1.3 I/O Device Types

Of all the I/O devices available under BDOS, the DSM services them without the use of interrupts. These devices are divided into three subsets according to the I/O operations they can perform and the manner in which they store data. The devices fall into Type 1, Type 2 and Type 3 devices, respectively.

In the descriptions that follow, the term "device" refers to a piece of physical I/O hardware, such as a disk drive, and the storage media mounted within it, such as a disk pack, which are treated together by the system as a single unit. The term "device name", when used in the descriptions below, refers to a set of names that are predefined within the DSM and are used to specify the devices which are available within the system. All device names consist of a slash (/) followed by 1 to 4 alphanumeric characters.

A Type 1 device has the characteristics that it may be read and written completely under program control. Since the system programs must be resident on a device with these characteristics, at least one Type 1 device, namely the system device, must always be available for the operation of BDOS. Moving or fixed head disk units and block addressable magnetic tape units are the typical devices that fall into this category.

Type 1 devices can each contain one or more files all of which can be open concurrently and accessed independently. The files stored on a given Type 1 device are called Type 1 files and are accessed by names that are stored in a file directory resident on the device. The names used to access these files are specified by the user and are unique within any one file directory. The manipulation of the file directory is accomplished by a set of file maintenance commands that are available only for Type 1 devices. These commands allow the user to define and delete files as well as obtain and modify certain protection flags associated with the files.

Before Type 1 files can be referenced, their names must be defined in the file directory on the device on which they are to be stored. Once defined, these files may be opened in sequential mode only under BDOS.

Type 2 devices, the magtape unit, are capable of accepting both of the basic I/O operations. The data may be written in sequential mode only. Write protection for Type 2 files is manually selected on the device on which the files are stored and is recognized appropriately by the device driver. As a result, the write protect function is a blanket function that applies simultaneously to all of the files on the device rather than to each file individually.

Type 3 devices are generally those devices which do not fit into either of the other two categories. These are the devices which are normally capable of being only read or written but not both and usually require manual positioning. Paper tape punches and readers, keyboard input devices, and visual output devices such as teletype printers fall into this category.

Each Type 3 device is considered to be a single file, called a Type 3 file, that is accessible only in sequential mode. The basic I/O operations that can be performed on these files depend entirely on the associated device. Generally however, they are restricted to either the read operation only or the write operation only and are normally not allowed the position operation.

The position of the end-of-file point in a readable Type 3 file may be a function of either the initial manual positioning of the device or of data input from the device and cannot be relied upon to occur repeatedly at the same point. Similarily, writing to a Type 3 file may assume some prior manual intervention in order to provide the proper output. Write protection is not normally provided for these files.

3.2.1.4 File Access Methods

The files available through BDOS appear to the user as strings of numbered 8 bit data bytes that can be read and/or written. The imaginary number associated with each byte indicates its relative position within the file such that, for a file comprised of N bytes, byte zero is the first byte, byte N-1 is the last byte, and the position that would be byte N is the end-of-file.

For the purpose of accessing the contents of a file, the operations open, read, write and close are provided by the BDOS DSM. The open operation is used to activate or open a file for I/O processing while the close operation deactivates or closes a file after I/O processing is complete. The read and write operations are the two basic I/O operations provided by the system.

Opening a file consists of specifying to the DSM where the file is stored and which buffer area, within the DSM, is to be used for accessing the file. The location where the file is stored is specified to the DSM by a string of ASCII characters called a file identifier. The file identifier tells the DSM the name of the device on which the file is resident.

The DSM buffer areas, called file slots, are predefined within the monitor and are specified by number. The total number of file slots in the monitor is fixed when the system is initially stored (generated) on the system device. Since only one file at a time can be open at any given file slot, this value determines the maximum number of files that can be simultaneously open within the system (four under BDOS).

Once the file is open the read, write and close operations all refer to the file by the number of the file slot at which it is open rather than its file identifier. Since most I/O drivers prohibit the user from opening the same file at two or more file slots simultaneously, the file slot becomes a unique way of selecting an open file.

Associated with each open file is an imaginary indicator, called the current position, that specifies the number of the next byte to be read or written. The current position of a file is set to zero when the file is opened and is altered subsequently by the execution of read and write operations. A read or write operation increments the current position by one for each byte transferred.

The read and write operations that are performed on an open file is performed in a block mode. That is, one or more data bytes are transferred directly to or from a buffer in user memory. The location and length of this buffer is specified to the DSM when the read or write command is issued. The block mode of operation can be used for any file regardless of the device on which it is stored.

Read operations can be performed in a file without modifying either its contents or length. The only restriction placed on this operation is that it may not move the current position of a file past its end-of-file point. Attempting to read a file beyond this point will cause the DSM to terminate the operation with an end-of-file error and leave the current position at the end-of-file.

Write operations, unlike read operations, are not restricted by the end-of-file and are, in fact, the normal means used to alter the length of a file and therefore, its end-of-file position. The only factor that limits the extent to which a file can be written is the storage area available on the device on which the file is resident.

The effect that a write operation has on a file is determined by the access mode in which the file is opened. The only access mode under BDOS which is available to all files, is called sequential mode. In sequential mode each write operation resets the end-of-file to the point immediately following the last byte written or, in other words, to the value of the current position following the write. As a result, writing a file in sequential mode may either increase or decrease its length. Should the latter case occur, the new end-of-file will make inaccessible the data previously existing beyond that point. A file just written in sequential mode may be read by closing and opening the file or by "rewinding" the file.

Due to its interactive nature, the operator's console is treated differently from other I/O devices. Instead of being accessed as a file, it is accessed directly on a character by character basis through the DSM. The console keyboard, and the console printer, or display, are treated independently and in a full duplex manner. As a result, characters that are read in must be echoed back out by the running program so that they may be seen by the console operator. The character input and character output functions are provided by the DSM and are available to the user's program at any time.

3.2.1.5 BDOS Operating Modes

The two modes of operation for BDOS are Executive Mode and User Mode. In the Executive Mode the user controls the system via the teletype with either file access commands or file maintenance commands. These commands are entered at the teletype and cause appropriate operations to be performed. After execution of the command, control of the system is returned to the user at the teletype. Detail information about the Executive Command mode of operation can be found in Section III of the XDOS Disk Operating System Manual.

In the User Mode, BDOS commands are embedded in the user's computer program. A BDOS command encountered in the user's program causes the appropriate operation to be performed, after which control is returned to the program statement following the execution of that command. In addition to file access commands and file I/O commands the user has available file maintenance commands for random access devices. The programmer may transfer from the user command mode to the executive command mode and from the executive command mode to the user command mode by applying the appropriate instruction. Detail information about the user command mode of operation can be found in Section IV of the XDOS Disk Operating System Manual.

3.3 Lineal to Raster Conversion Module

The Lineal to Raster Conversion (LRC) module produces raster data which is acceptable to the DACOM K661A plotter controller. Certain constraints which had to be adhered to proved very critical in the LRC design. The two major constraints were (1) memory size (24K of 16-bit words) and (2) the availability of the sequential disk access method only.

The concept which has been adopted due to the constraints is two-fold. First, three overlays (each within the memory constraints) are executed sequentially to produce the final raster data file. Secondly, a one raster line at a time processing method had to be adopted. This method (as opposed to spot array generation methods) reduces the memory required to process a feature (lineal or area) to the number of cells required to hold one raster line. For a raster line 24 inches in length (worst case), only 24000 bits are required to represent it at a 1 mil resolution. For the NOVA 1220, this amounts to 1500 computer words.

To present a total concept description of the LRC module, it is first necessary to understand the data which is processed and the data which is output. Next, each overlay can be described as a unit. Each pertinent concept within an overlay can then be presented with the overall LRC process in mind.

3.3.1 Lineal to Raster Input Data Format

The LRC input data consists of the Bendix System lol (Version 3) output data. The data is contained within two types of files: the drawing file and the symbol file. The drawing file consists of variable length records as described in Figure No. 3-1 through 3-10. Each record contains a "KEY" which denotes both the type and length of the record.

The symbol file's first 200 words is a lookup table of pointers which indicate where each symbol is stored in the file. The pointers contain the word position for the start of each symbol. Since the lookup table uses the first two hundred positions, symbol storage begins at word position 201. The pointer for each symbol is stored in its respective word position - for example - the pointer for symbol number 1 would be in word position 1 and the pointer for symbol number 155 would be stored in word position 155. The first symbol is stored beginning at word position 201 but need not be symbol number 1. For example, suppose that symbol number 8 was created and stored first, then the pointer in word position 8 would point to word position 201. Now, if symbol number 8 required 56 word positions for storage, then the next symbol to be stored would be stored starting at word position 257 and its respective pointer would be set to 257. The pointers in a symbol file are initially set to a value of 32, the null address. The data for each symbol looks exactly like a complete drawing (which it really is) including the "END" code (31).

Note that the text records (type 16 & 17) include only ASCII characters. In order to generate the required characters, a special symbol file has been generated (See Section 5). This file is referenced only when text records are encountered. The existing text symbol file is used to process only "FUTURA MEDIUM" font of any desired height. Justification is available only in the vertical direction. There is no capability to produce the characters as screened areas since the text file was produced as solid/blank areas. Figure No. 3-11 shows the correlation between the available characters and their pointer positions in the file's first 200 words.

WORD	FIELD	DESCRIPTION
Ø	KEY (BITS Ø-7) LENG (BITS 8-15)	KEY = 1 LENG = 1Ø (RECORD LENGTH)
1	ISUBF	ISUBF = Ø-999 (SUBFILE)
2	LWIDE (BITS Ø-7) LTYPE (BITS 8-15)	LWIDE = PEN NUMBER LTYPE = LINETYPE
3-4	X (BITS Ø-31)	X COORDINATE (REAL)
5-6	Y (BITS Ø-31)	Y COORDINATE (REAL)
7	MENUN ID1	NOT USED
8	ID2 ID3	NOT USED
9	ID4 ID5	NOT USED

RECORD TYPE 1: PEN UP

Figure No. 3-1

WORD	FIELD	DESCRIPTION
Ø	KEY (BITS Ø-7 LENG (BITS 8-15)	KEY = 3 LENG = 12 (RECORD LENGTH)
1	ISUBF	ISUBF = Ø-999 (SUBFILE)
2	LWIDE (BITS Ø-7) LTYPE (BITS 8-15)	LWIDE = PEN NUMBER LTYPE = LINE TYPE
3-4	X (BITS Ø-31)	X COORDINATE OF CENTER (REAL)
5-6	Y (BITS Ø-31)	Y COORDINATE OF CENTER (REAL)
7-8	RAD (BITS Ø-31)	RADIUS OF CIRCLE (REAL)
9	MENUN ID1	NOT USED
10	ID2 ID3	NOT USED
11	ID4 ID5	NOT USED

RECORD TYPE 3: CIRCLE

Figure No. 3-2

WORD	FIELD	DESCRIPTION
Ø	KEY (BITS Ø-7) LENG (BITS 8-15)	KEY = 4 LENG = 24 (RECORD LENGTH)
1	ISUBF	ISUBF = Ø-999 (SUBFILE)
2	LWIDE (BITS Ø-7) LTYPE (BITS 8-15)	LWIDE = PEN NUMBER LTYPE = LINE TYPE
3-4	X (BITS Ø-31)	X COORDINATE OF ARC CENTER (REAL)
5-6	Y (BITS Ø-31)	Y COORDINATE OF ARC CENTER (REAL)
7-8	RAD (BITS Ø-31)	RADIUS OF ARC (REAL)
9-10	THETØ (BITS Ø-31)	INITIAL ANGLE OF ARC IN RADIANS (REAL)
11-12	THETF (BITS Ø-31)	FINAL ANGLE OF ARC IN RADIANS (REAL)
13-14	COSØ (BITS Ø-31)	COS OF ARC'S INITIAL ANGLE (REAL)
15-16	SINØ (BITS Ø-31)	SIN OF ARC'S INITIAL ANGLE (REAL)
17-18	COSF (BITS Ø-31)	COS OF ARC'S FINAL ANGLE (REAL)
19-20	SINF (BITS Ø-31)	SIN OF ARC'S FINAL ANGLE (REAL)
21	MENUN ID1	NOT USED
22	ID2	NOT USED
23	ID3	NOT USED

RECORD TYPE 4: CLOCKWISE ARC

Figure No. 3-3

WORD	FIELD	DESCRIPTION
Ø	KEY (BITS Ø-7) LENG (BITS 8-15)	KEY = 5 LENG = 24 (RECORD LENGTH)
1	ISUBF	ISUBF = Ø-999 (SUBFILE)
2	LWIDE (BITS Ø-7) LTYPE (BITS 8-15)	LWIDE = PEN NUMBER LTYPE = LINE TYPE
3-4	X (BITS Ø-31)	X COORDINATE OF ARC CENTER (REAL)
5-6	Y (BITS Ø-31)	Y COORDINATE OF ARC CENTER (REAL)
7-8	RAD (BITS Ø-31)	RADIUS OF ARC (REAL)
9-10	THETØ (BITS Ø-31)	INITIAL ANGLE OF ARC IN RADIANS (REAL)
11-12	THETF (BITS Ø-31)	FINAL ANGLE OF ARC IN RADIANS (REAL)
13-14	COSØ (BITS Ø-31)	COS OF ARC'S INITIAL ANGLE (REAL)
15-16	SINØ (BITS Ø-31)	SIN OF ARC'S INITIAL ANGLE (REAL)
17-18	COSF (BITS Ø-31)	COS OF ARC'S FINAL ANGLE (REAL)
19-20	SINF (BITS Ø-31)	SIN OF ARC'S FINAL ANGLE (REAL)
21	MENUN ID1	NOT USED
22	ID3	NOT USED
23	ID4 ID5	NOT USED

RECORD TYPE 5: COUNTER-CLOCKWISE ARC

Figure No. 3-4

WORD	FIELD	DESCRIPTION
Ø	KEY (BITS Ø-7) LENG (BITS 8-15)	KEY = 6 LENG = 1Ø (RECORD LENGTH)
1	ISUBF	ISUBF = Ø-999 (SUBFILE)
2	LWIDE (BITS Ø-7) WTYPE (BITS 8-15)	LWIDE = PEN NUMBER LTYPE = LINE TYPE
3-4	X (BITS Ø-31)	X COORDINATE (REAL)
5-6	Y (BITS Ø-31)	Y COORDINATE (REAL)
7	MENUN ID1	NOT USED
8	ID2 ID3	NOT USED
9	ID4 ID5	NOT USED

RECORD TYPE 6: PEN DOWN

Figure No. 3-5

WORD	FIELD	DESCRIPTION
Ø	KEY (BITS Ø-7) LENG (BITS 8-15)	KEY = 7 LENG = 15 (RECORD LENGTH)
1	ISUBF	ISUBF = Ø-999 (SUBFILE)
2	NSYMB	SYMBOL NUMBER (1-2ØØ)
3-4	X (BITS Ø-31)	X COORDINATE OF SYMBOL ORIGIN (REAL)
5-6	Y (BITS Ø-31)	Y COORDINATE OF SYMBOL ORIGIN (REAL)
7-8	ANGLE	SYMBOL ANGLE IN RADIANS (REAL)
9	MIRROR FLAG	Ø = NORMAL 1 = MIRROR
10-11	SKLSY	SYMBOL SCALE (REAL)
12	MENUN ID1	NOT USED
13	ID2 ID3	NOT USED
14	ID4 ID5	NOT USED

RECORD TYPE 7: SYMBOL REFERENCE

Figure No. 3-6

WORD	FIELD	DESCRIPTION
Ø	KEY (BITS Ø-7) LENG (BITS 8-15)	KEY = 8 LENG = 15 (RECORD LENGTH)
1	ISUBF	ISUBF = Ø-999 (SUBFILE)
2	LWIDE (BITS Ø-7) IFONT (BITS 8-15)	LWIDE = PEN NUMBER IFONT = FONT NUMBER
3-4	X (BITS Ø-31)	X COORDINATE OF TEXT ORIGIN (REAL)
5-6	Y (BITS 031)	Y COORDINATE OF TEXT ORIGIN (REAL)
7	JUSTF	TEXT JUSTIFICATION
8-9	TEXTH (BITS Ø-31)	TEXT HEIGHT (REAL)
10-11	ANGLE (BITS Ø-31)	ANGLE OF TEXT ROTATION IN RADIANS (REAL)
12	MENUN ID1	NOT USED
13	ID2 ID3	NOT USED
14	ID4 ID5	NOT USED

RECORD TYPE 8: TEXT POSITION, NORMAL

Figure No. 3-7

WORD	FIELD	DESCRIPTION
Ø	KEY (BITS Ø-7) LENG (BITS 8-15)	KEY = 16 LENG = $\frac{NCHAR+1}{2}$ +3 (RECORD LENGTH)
1	ISUBF	ISUBF = Ø-999 (SUBFILE)
2	NCHAR	NUMBER OF CHARACTERS
3	CHAR(Ø) (BITS Ø-7) CHAR(1) (BITS 8-15)	CHARACTER Ø (ASCII) CHARACTER 1 (ASCII)
$\frac{NCHAR+1}{2}$ +2	CHAR (NCHAR-1) (BITS Ø-7) CHAR (NCHAR) (BITS 8-15)	CHARACTER (NCHAR-1) (ASCII) CHARACTER (NCHAR) (ASCII)

RECORD TYPE 16: TEXT STRING, NORMAL

Figure No. 3-8

WORD	FIELD	DESCRIPTION
Ø	KEY (BITS Ø-7) LENG (BITS 8-15)	KEY = 16 LENG = $\frac{\text{NCHAR+1}}{2}$ +3 (RECORD LENGTH)
1	ISUBF	ISUBF = Ø-999 (SUBFILE)
2	NCHAR	NUMBER OF CHARACTERS
3	CHAR(Ø) (BITS Ø-7) CHAR(1) (BITS 8-15)	CHARACTER Ø (ASCII) CHARACTER 1 (ASCII)
$\frac{\text{NCHAR+1}}{2}$ +2	CHAR (NCHAR-1) (BITSØ-7) CHAR (NCHAR) (BITS 8-15)	CHARACTER (NCHAR-1) (ASCII) CHARACTER (NCHAR) (ASCII)

RECORD TYPE 17: TEXT STRING, VARIABLE

Figure No. 3-9

WORD	FIELD	DESCRIPTION
Ø	KEY (BITS Ø-7) LENG (BITS 8-15)	KEY = 31 LENG = 1 (RECORD LENGTH)

RECORD TYPE 31: END OF FILE

Figure No. 3-10

POINTER POSITION	CHARACTER	ASCII* CODE	POINTER POSITION	CHARACTER	ASCII* CODE
1	A	101	31	?	77
2	B	102	32	;	73
3	C	103	33	:	72
4	D	104	34	&	46
5	E	105	35	-	55
6	F	106	36	%	45
7	G	107	37	1	61
8	H	110	38	2	62
9	I	111	39	3	63
10	J	112	40	4	64
11	K	113	41	5	65
12	L	114	42	6	66
13	M	115	43	7	67
14	N	116	44	8	70
15	O	117	45	9	71
16	P	120	46	Ø	60
17	Q	121	47	$	44
18	R	122	48	Space	40
19	S	123	49	+	53
20	T	124	50	/	57
21	U	125	51	=	75
22	V	126	52	"	42
23	W	127	53	#	43
24	X	130	54	*	52
25	Y	131	55	(	50
26	Z	132	56	)	51
27	!	41	57	N/A	N/A
28	. (PERIOD)	56	.	.	.
29	,	54	.	.	.
30	'	47	200	N/A	N/A

*ASCII CODES ARE OCTAL VALUES

TEXT SYMBOL FILE POINTER TABLE

Figure No. 3-11

3.3.2 Lineal to Raster Conversion Internal Data Format

The LRC module processes the drawing, symbol and text file data. From that data, it produces a set of triplets which will later be transformed into raster data. The triplets are in the form shown in Figure No. 3-12. These triplets are sorted in ascending order by X,Y within X and by Z (code). Eventually each X of the same value will represent one scan/plot line. Each Y within X will represent the position of a video unit (on or off) along the scan/plot line. The last word in the triplet (Z) contains two codes. The first code is the START/STOP/POINT code ($Z_\emptyset$) and the second code is the FILL TYPE (Z_1). The Z_1 code denotes that the (X,Y) belongs to either an enclosed feature, a blank area, a solid area or one of two screened areas. The $Z_\emptyset$ code denotes whether the (X,Y) is the start or stop of the area denoted by the Z_1 code or a point in itself.

3.3.3 Raster Data Format

The Raster Data Format is represented in Figure No. 3-13. This data is the vehicle for plotting graphics on the K661A Plotter. The figure shows both the data representation in the computer memory and the magnetic tape. The FN field denotes the file number assigned to the file records by the user. The CA field is the carriage address (or plot/scan line derived from the LRC produced triplets (X,Y,Z). The WC field denotes the data word count (not including the header). The RS field specifies the resolution of the data and the DM field the data mode.

Figure No. 3-14 shows the Data Mode Formats. These are the Serial Bit Stream (SBS) and the Run Length Code (RLC) data modes. These data modes are never intermixed within one file.

Figure No. 3-15 shows the inter-record format within magnetic tapes. Each tape can contain as many files as its length will allow. Each file is separated by an end of file (EOF). If a file must be split between tapes, the normal EOF mark is not written. The physical end of tape (EOT) is used to denote continuation. The next file record is simply started at the loadpoint (BOT) of a new tape.

WORD	FIELD	DESCRIPTION
Ø	IX	X COORDINATE POINT
1	IY	Y COORDINATE POINT
2	$Z_Ø$ (BITS Ø-7) Z_1 (BITS 8-9	*Z_0 = START/STOP/POINT CODE *Z_1 = FILL TYPE CODE

*$Z_Ø$ = Ø ; START CODE
= 1 ; STOP CODE
= 2 ; POINT CODE

*Z_1 = Ø ; BLANK AREA
= 1 ; SOLID AREA
= 2 ; HALF TONE (200 OPI/45%
= 3 ; HALF TONE (120 LPI/17%)
= 4 : ENCLOSED FEATURE

LRC INTERNAL DATA FORMAT

Figure No. 3-12

COMPUTER MEMORY

WORD	Ø – 7	8 – 15	
WORD Ø	FN		HEADER
1	CA		HEADER
2	WC		HEADER
3	RS	DM	HEADER
4	BYTE Ø	BYTE 1	DATA
5	BYTE 2	BYTE 3	DATA
6	BYTE 4	BYTE 5	DATA
⋮	⋮	⋮	DATA
(K/2) + 4	BYTE K	BYTE K + 1	DATA

MAGNETIC TAPE

FRAME	Ø – 7	
FRAME Ø	FN (HIGH ORDER)	HEADER
1	FN (LOW ORDER)	HEADER
2	CA (HIGH ORDER)	HEADER
3	CA (LOW ORDER	HEADER
4	WC (HIGH ORDER)	HEADER
5	WC (LOW ORDER)	HEADER
6	RS	HEADER
7	DM	HEADER
8	BYTE Ø	DATA
9	BYTE 1	DATA
10	BYTE 2	DATA
11	BYTE 3	DATA
12	BYTE 4	DATA
13	BYTE 5	DATA
⋮	⋮	DATA
K + 8	BYTE K	DATA
K + 9	BYTE K + 1	DATA

LEGEND:

FN = File Number [Ø≤FN≤32767]
CA = Carriage Address [Ø≤CA≤32767]
WC = Data Word Count [Ø≤WC≤32767]
RS = Data Resolution[Ø=1000LPI: 1=800LPI:2=600LPI;3=500LPI;4=400LPI]
DM = Data Mode [2=SBS; 3=RLC]

Figure No. 3-13 RASTER DATA RECORD FORMAT

	Ø	1	2	3	4	5	6	7
BYTE Ø	V_0	V_1	V_2	V_3	V_4	V_5	V_6	V_7
1	V_8	V_9	V_{10}	V_{11}	V_{12}	V_{13}	V_{14}	V_{15}
⋮								
((n+1)/8)-1	V_{n-7}	V_{n-6}	V_{n-5}	V_{n-4}	V_{n-3}	V_{n-2}	V_{n-1}	V_n

LEGEND:

V_k: VIDEO BIT [Ø=Video Off; 1= Video On]

SBS DATA MODE

	Ø	1 2 3 4 5 6 7
BYTE Ø	$V_Ø$	RLC_0
1	V_1	RLC_1
⋮		
	V_n	RLC_n

LEGEND:

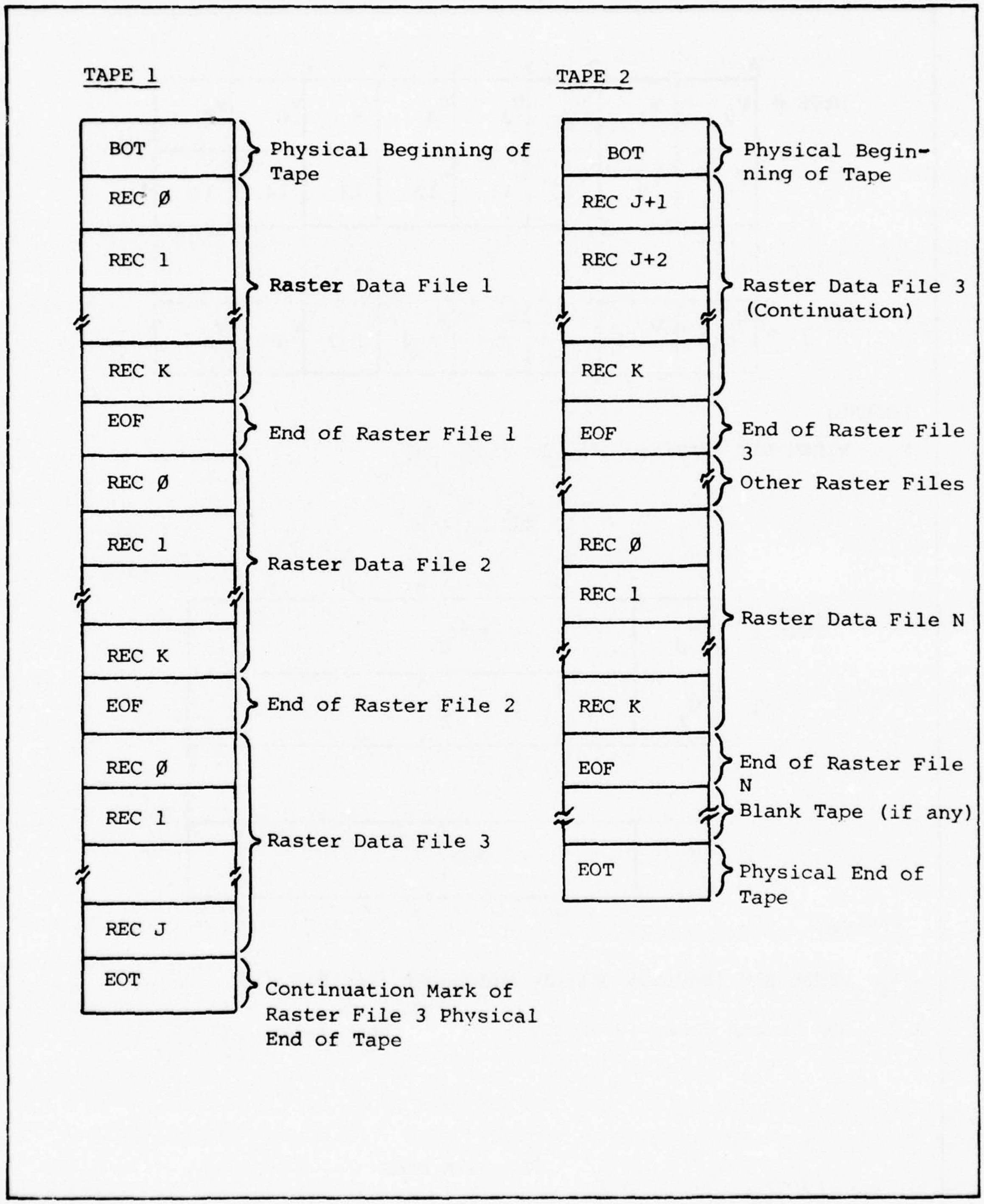
V_k Video Bit [Ø=Video Off; 1= Video On] (bit Ø)

RLC: Run Length Count [$Ø \leq RLC \leq 127$] (bit 1-7)

RLC DATA MODE

DATA MODE FORMATS

Figure No. 3-14



INTER-RECORD FORMAT

Figure No. 3-15

3.4 LRC Overlay 1 (SETUP)

The first overlay which is executed in the LRC process is called SETUP. As the name suggests, it sets up the input data on the system disk. The disk unit contains a user platter (removable) and a system platter (fixed). Since the user platter may not contain enough usable space to process the input data into the internal format, the user data is moved to the system platter. When transferring the data, all deleted records (denoted by a subfile number Ø) are bypassed. Any records of a drawing file which have been chosen to be disregarded via the subfile number selection option are also by passed. The new drawing file on the system platter contains only the data which is to be processed. Note that both the user's symbol file and the text file are transferred without the subfile number selection option. Deleted records are bypassed, though.

Once the new drawing, symbol and text file are on the system platter, the user's platter is removed and a working platter (no files) is mounted in its place. All processing of the input data is performed on this new platter.

3.5 LRC Overlay 2 (PHASE1)

The second overlay which is executed in the LRC process is called PHASE1. It is the first of a two phase process to produce the raster data file. The end product of PHASE1 is a data file containing a sorted (ascending order) set of triplets as described in section 3.3.2. These triplets define the outer boundary of areal data. That is, all the input data which is processed are reduced to areas.

3.5.1 PHASE1 File Manipulation

The file manipulation for PHASE1 is restricted by the four (4) file slots available in BDOS. As many as three (3) slots are required for the input data (drawing, symbol, text files). The sort/merge process which enjoins new feature data with those features which have already been processed requres three (3) more slots. As one can see from the above, six (6) slots are required while only four (4) are available. Recall that all file manipulation is being performed in the sequential access mode (the only available mode).

The above problem is resolved by utilizing the symbol and text file slots in a dual mode. Each time either of the two files is being read, pointers are maintained which specify which data word had been read. Whenever either of the two slots are required by the sort/merge, they must be relinquished (closed). When the sort/merge is complete, the relinquished slots are reopened and sequentially read up to the pointer maintained for that slot. This process is rather slow if the pointer is a large magnitude.

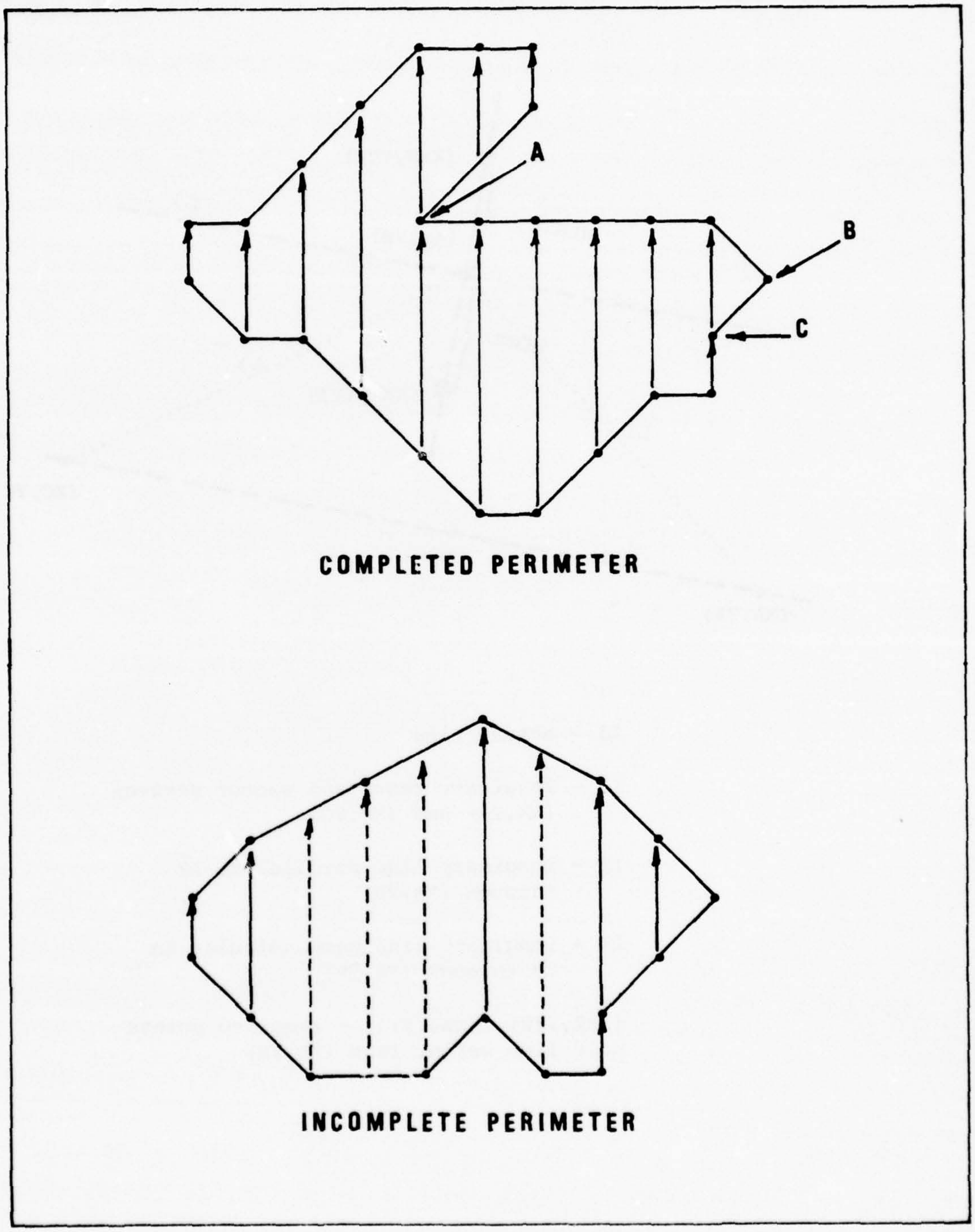
3.5.2 Feature Generation

As mentioned before a feature (lineal or area) is transformed into an area. The area perimeter must contain enough points to fill all the one (1) mil (required resolution) grids along its path. Figure No. 3-16 shows an area perimter with and without enough grid points along the perimeter. If not all the grid points are filled gaps will occur along the raster line where the point(s) are missing.

The completed perimeter contains enough points to be able to generate raster triplets. Note that some points (A and C) must be duplicated as both a start and a stop triplet. Point B is an example of a point in itself, therefore, not requiring a start and stop code. The incomplete perimeter will generate gaps as shown by the dashed raster lines. This occurs whenever a grid point is not selected along the perimeter.

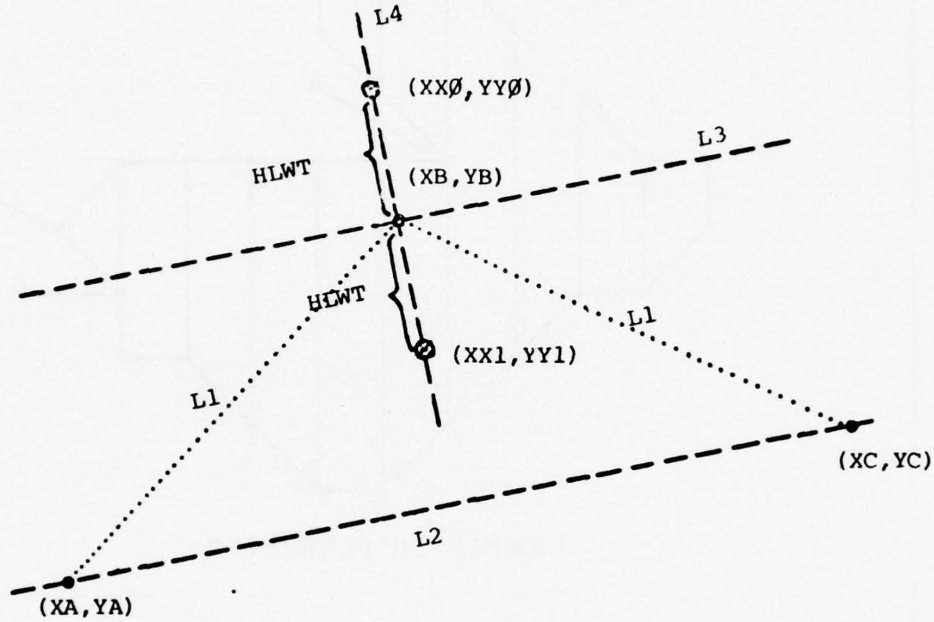
Whenever a feature is digitized as an area (blank, solid or half tone), all need be done is interpolate between each digitized point to ensure a complete perimeter and set the appropriate fill code to denote the area type. If the area digitized is either a circle or an arc, special routines are utilized to generate all the points needed along their respective circumferences.

Whenever a feature is digitized as a center line with a given lineweight, the sleeve (perimeter) points for the center line must be generated and a fill type which is solid denoted. The sleevepoint algorithm takes three points (XA,YA), (XB,YB), (XC,YC) as in Figure No. 3-17and manipulates them in the following manner.



AREA PERIMETERS

Figure No. 3-16



L1 - actual line

L2 - imaginary resultant vector between (XA,YA) and (XC,YC)

L3 - imaginary line parallel to L2 through (XB,YB)

L4 - imaginary line perpendicular to L3 through (XB,YB)

(XXØ,YYØ), (XX1,YY1) - required points half line weight from (XB,YB)

SLEEVE POINTS GENERATION

Figure No. 3-17

(1) Construct imaginary resultant vector L2

(2) Construct imaginary line L3 parallel to L2 through the point (XB,YB)

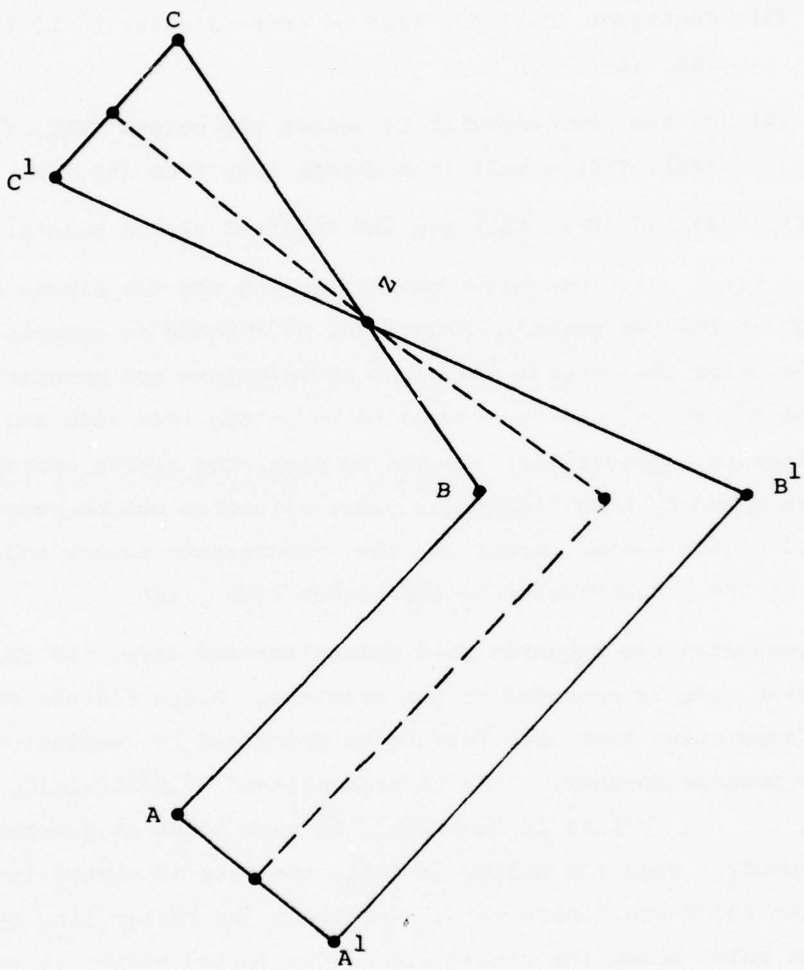
(3) Construct imaginary line L4 perpendicular to L3 through (XB, YB)

(4) On the perpendicular L4 select the points (XXØ, YYØ), and (XX1, YY1) a half line weight away from (XB, YB).

The points (XXØ,YYØ) and (XX1, YY1) are the required sleeve points.

One major error which can occur when selecting the two sleeve points is the "flipping" of the two points. Figure No. 3-18 shows an example of the problem. When using the general algorithm above points are generated such that A,B,C and A^1, B^1, C^1 are considered to be on the left side and right side of the feature respectively. As can be seen, the sleeve crosses at Z because points C and C^1 have "flipped". This situation can be remedied by keeping record of the vector direction, the Y-coordinate values and the sign of the slope of the perpendicular to the center line point.

Having generated the required grid points for the area, the appropriate start/stop/point code is appended to the triplets. Since feature areas may cross, it is imperative that each feature be processed to completion before attempting to process another. This is accomplished by maintaining temporary files on disk for the feature in question. As each point is generated, it is buffered in memory. When the buffer is full, the data is sorted in ascending order such that the X-coordinate value represents the raster line and the Y-coordinate the point along the raster line. The sorted buffer is then merged with the features temporary file. When the feature is complete, the file read into memory again and the start/stop/point codes are set. As each buffer is processed, it is merged with the main feature file. This file will contain all the data for every feature.



FLIPPING OF SLEEVE POINTS

Figure No. 3 -18

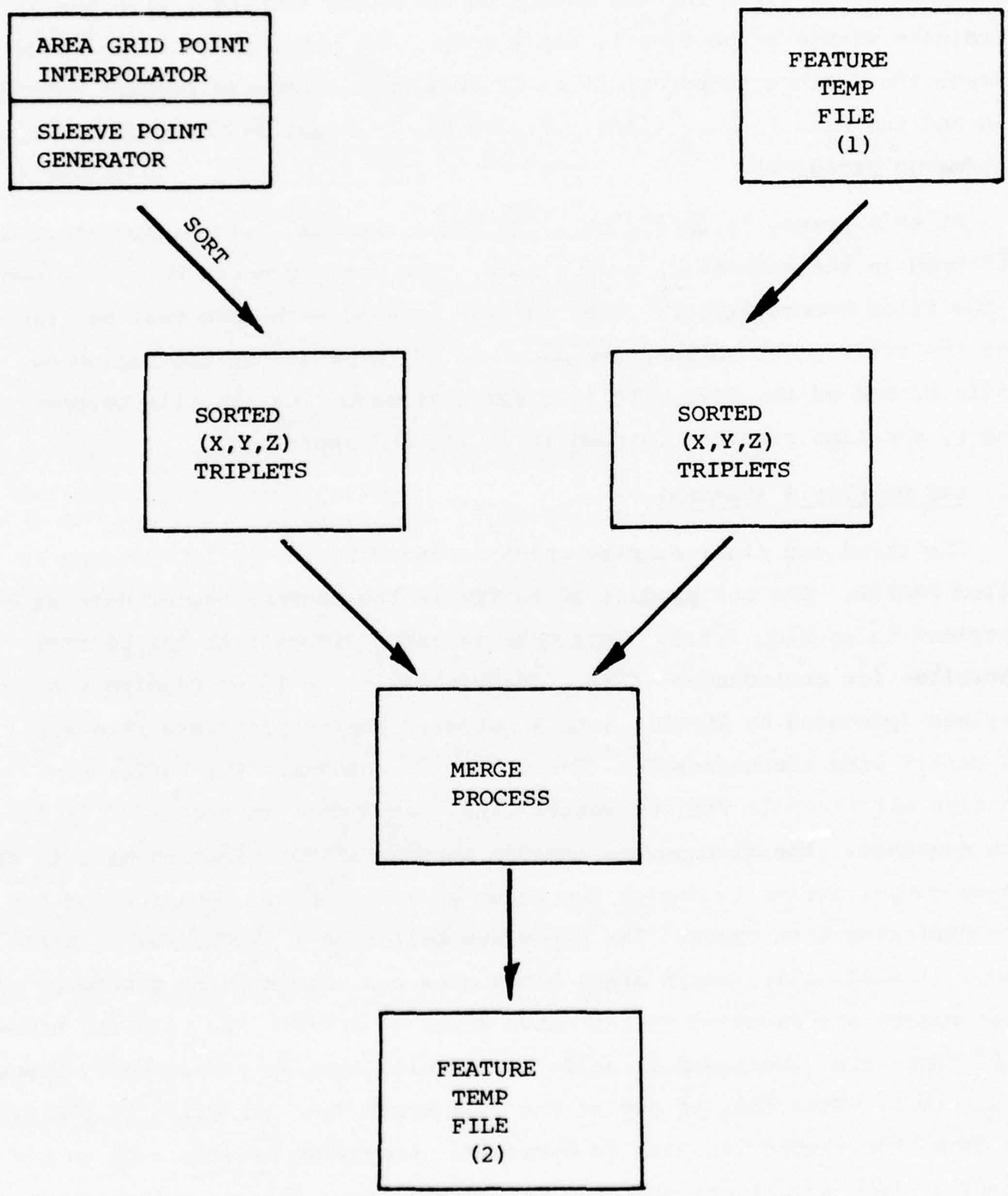
3.5.3 Sort/Merge Process

The sort/merge process consists of a fast comparative, interchange sort and a sequential merge between two (3) files. The sort selects the X-coordinate value first for the ascending collating sequence, then the Y-coordinate within X and finally the Z code. The merge process can occur between the feature temporary files or between a completed feature temporary file and the main feature files. Figure No. 3-19 and 3-20 depict the two sort/merge processes.

At this point, it should be noted again that all file manipulation is performed in the sequential access mode. The merge process becomes slower as the files become larger. This is true because each file must be read from its start point whether the data was to be merged at the beginning, middle or end of the file. It is clear that each time the file becomes longer, the time required to read it to its end increases.

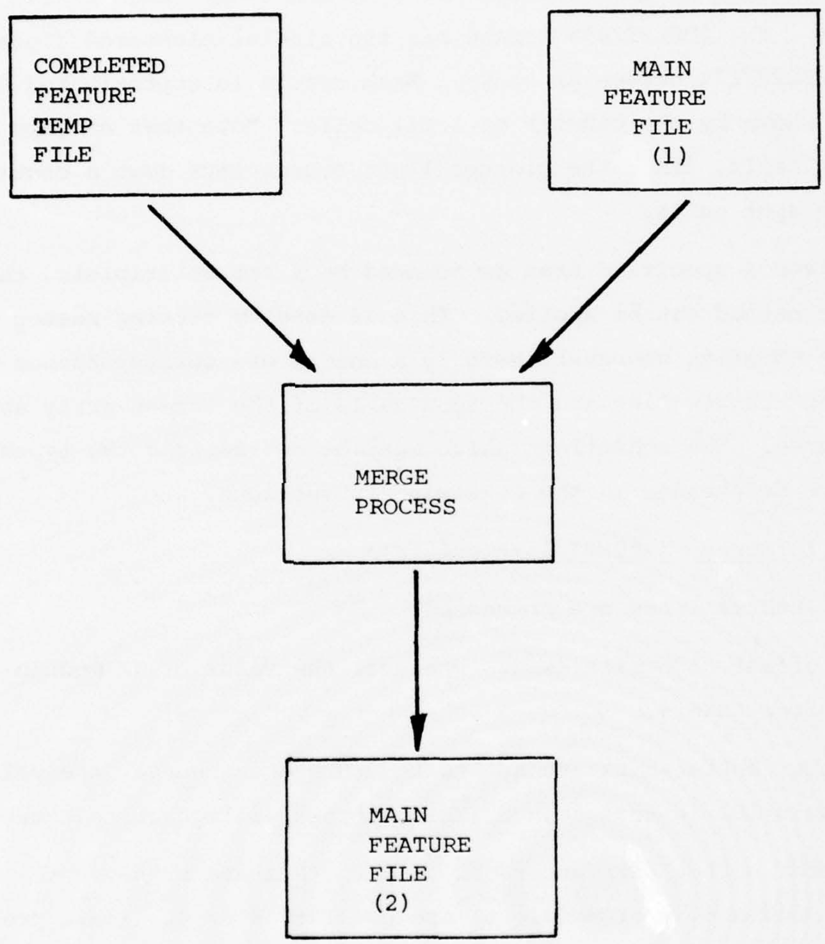
3.6 LRC Overlay 3 (PHASE2)

The third and final overlay which is executed in the LRC process is called PHASE2. The end product of PHASE2 is the magtape raster data as described in section 3.3.3. This data is input directly to the plotter controller for recording on film. The processing includes reading the triplets (produced by PHASE1) into a buffer. The triplets are read until the raster line identification (X-coordinate) changes. The buffer now contains all the data for one raster line. This data is processed in five pass sequence. The five passes include setting and/or clearing bits in the raster output buffer to depict the video on/off sequence required for the five differing area types. The types are half tone 1 (200LPI/45%), half tone 2 (120LPI, 17%), solid area, blank area and sleeve point generated area. These passes are executed in the above order to achieve the required hiearchy (half tones are overlayed by solid area, solid area is overlayed by blank area, etc.). Note that if any of the fill types does not exist in the triplet data, the respective pass is bypassed. Provision is also made to generate blank scan lines whenever intervening X-coordinate values are missing (X=26, 27 BLANK,BLANK,BLANK,31,32,etc.).



FEATURE TEMPORARY FILE SORT/MERGE

Figure No. 3-19



MAIN FEATURE FILE MERGE

Figure No. 3- 20

3.6.1 Screened Areas

The screened area process requires that solid circle areas be generated in the matrix form shown in Figure No. 3-21 and 3-22. Each circle is 5 mil in diameter. The 200LPI/45% screen has the circles clustered closer together then the 120LPI/17% screen as shown. Each circle is approximated by an octagon as shown by the cluster of 1 mil cells. Note that no gaps will exists between the cells, since the plotter light source lays down a continuous line rather than spot cells.

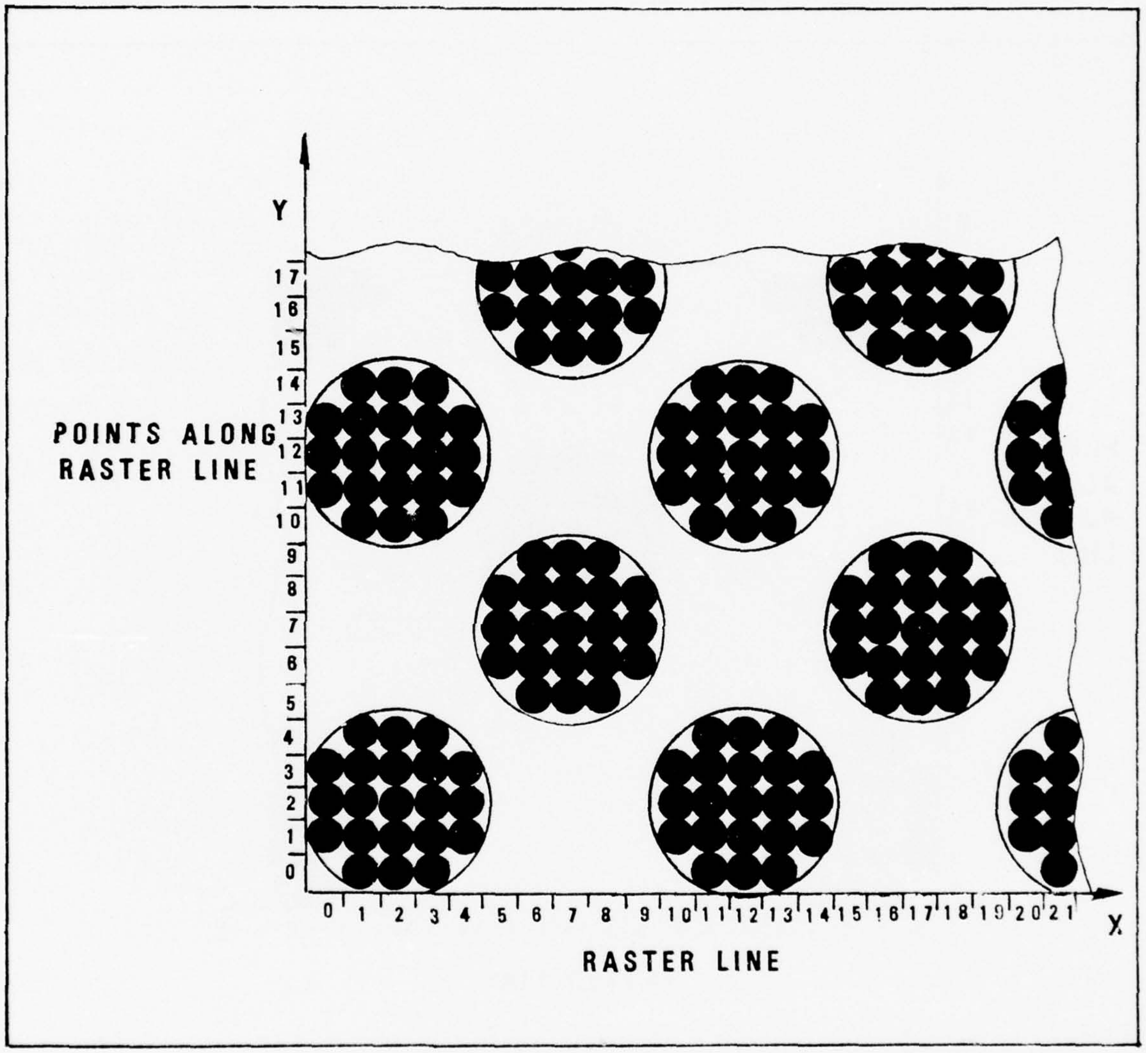
To screen a specified area as bounded by a set of triplets, the one raster line method can be applied. This is done by setting raster buffer bits to the ON state whenever there is a one to one correspondence between the "working" raster line and the spot cells of the screen array as shown in the figures. The conditions which must be met for the two types of screened areas are deleneaded in the following subsections.

3.6.1.1 Screen (200LPI/45%) Criteria

- √ All raster lines are processed
- √ An offset of 5 mils exists whenever the value of (X modulo 1Ø) is greater than 4.
- √ Raster buffer bits are set to the ON state whenever the value of (Y modulo 10) is less than 5 (This process will generate squares)
- √ Raster buffer bits are reset to the OFF state whenever the value of (X modulo 5 and Y modulo 5) are equal to Ø or 4. (This process removes the corners from the square to form the octagon)

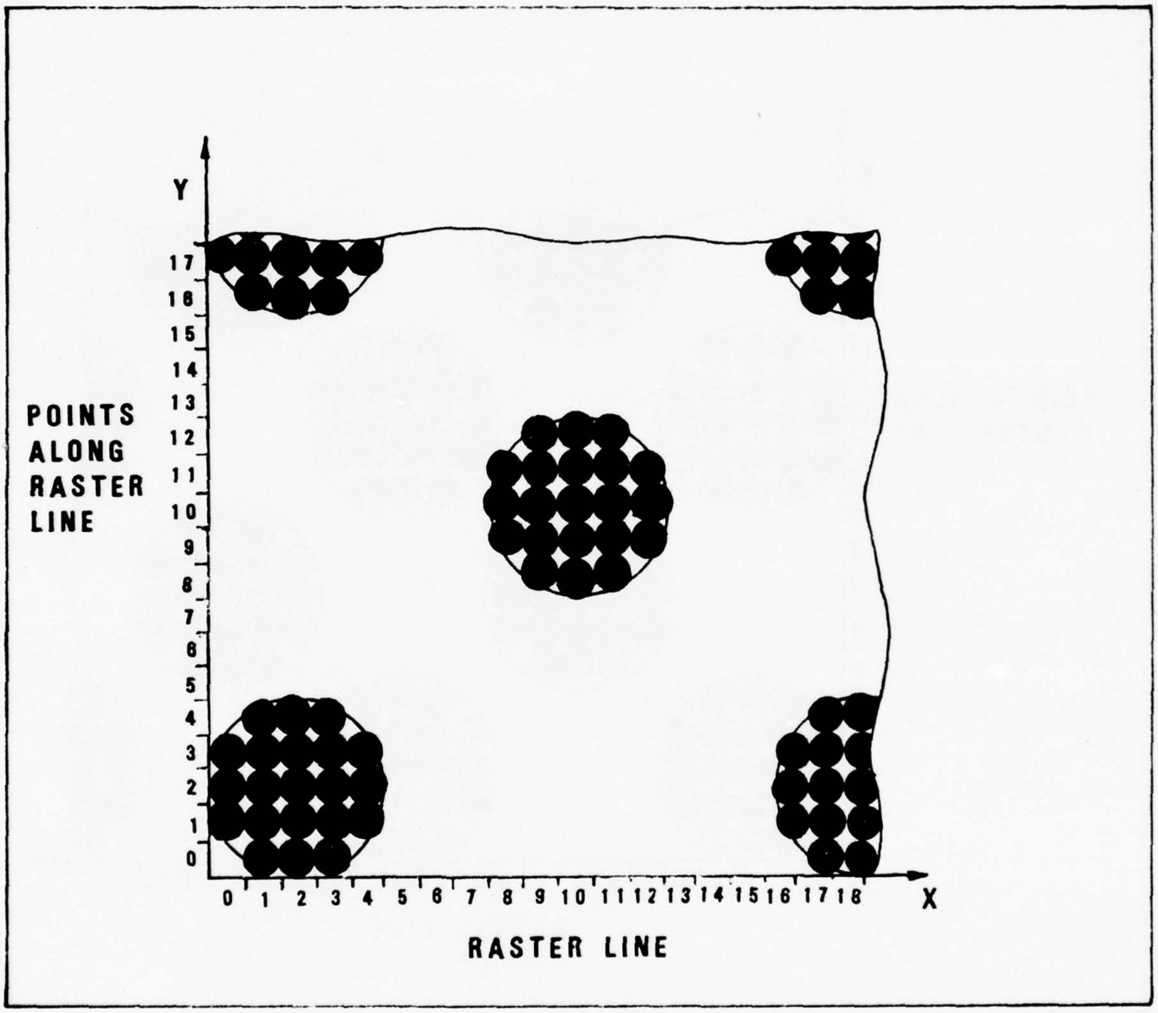
3.6.1.2 Screen (120LPI/17%) Criteria

- √ Raster lines are processed whenever the value of (X modulo 8) is less than 5.
- √ An offset of 8 mils exists whenever the value of (X modulo 12) is greater than 7.



200 LPI / 45% SCREEN GRID

Figure No. 3-21



120 LPI / 17% SCREEN GRID

Figure No. 3-22

- √ Raster buffer bits are set to the ON state whenever the value (Y modulo 16) is less than 5. (This process will generate squares)
- √ Raster buffer bits are reset to the OFF state whenever the value of (X modulo 8 and Y modulo 16) are equal to Ø OR 4. (This process removes the corners from the square to form the octagon)

3.6.2 Solid/Blank/Sleeved Areas

Solid and sleeved (solid with higher priority) areas are generated by scanning the given triplets for a raster line for the start/stop/point codes. Raster buffer bits are set to the ON state between a start and stop code. If a point code is found, only the one point is processed. Blank areas are generated in a similar manner except that raster buffer bits are reset to the OFF state.

The bit set/reset function is processed by a special program which performs the function (set/reset) on whole computer words instead of one bit at a time. Thus, much processing time is saved.

SECTION 4

BENDIX SYSTEM 101

4.1 General

The Bendix System 101 documentation and proprietary software was procured from Bendix and an analysis of the system was made. Although the documentation was sparse, the software code provided a good insight to the computer modules utilized in the system. Due to the constraints of the contract, i.e. six (6) month duration, it was decided and the government approved that no software modification should be made to the Bendix software. The inherent capabilities of the system lended itself to the digitizing requirements of the FLIP graphics. The menu device which is used by the Bendix digitizing system was revised such that the data output could be processed by the lineal to raster conversion module. The modification of the menu consists of utilizing the PEN fields for LINEWEIGHT and AREA feature types. The following subsections present a summary of the Bendix System 101 capabilities along with the menu modification fields.

4.2 Menu Description

The menu, as provided to RADC/DMAAC, is divided into six categories starting with File Control on the left-hand side of the menu, followed by Editing Modes, Keyboard Functions, Operation, Lineweight/Area Type Selection and Symbols.

4.2.1 File Control

Three types of disk files are available to the operator at all times. The first type of file, labeled "Drawing" on the menu, is used essentially for permanently storing finished drawings generated by the system. This type of file can also be used, if need be, to create drawing symbols and is accessed when revisions are to be made to drawings already in storage.

The second type of file, labeled "Scratch" on the menu, is used primarily for producing drawing symbols and parts of drawings that are not conceptualized sufficiently for entry into drawing files. In function, this type of file is

much like scratch paper in that it is used on a temporary basis. As a result, the operator is allowed to experiment with the graphics being generated without disturbing the permanent drawing files.

The last type of file, labeled "Symbol" under File Control on the menu, is used to permanently store any of the special drawing symbols created in the drawing or scratch file. Each symbol file can contain 200 symbols. Although it is possible to have a number of different symbol files, only one of these files can be used at a time.

In file control there are seven different commands. The NEW command, which pertains to the drawing and symbol files, is used when the operator has completed work on the present drawing or symbol file. This command accomplishes the following:

- o Permanently stores the present drawing or symbol file.
- o Allows the operator to select the next file to be worked on. This file may be an existing one which he wishes to modify or a new one which he will create.

The ACTIVATE AND DISPLAY command for both the drawing and scratch files relates to the display terminal. When this command is given, the computer sends the contents of the file to the CRT terminal for display. This command performs a dual function in that it automatically enables the displayed file to accept further data. The display can be aborted at any time by depressing the CONTROL and D keys on the teleprinter's keyboard. (Note that features digitized as areas will always be displayed as blank areas and features assigned a particular line weight will be displayed as a thin (15 mil line).

Beneath ACTIVATE AND DISPLAY is the CLEAR command. When this command is issued, the computer simply erases everything stored in that file. Since the drawing file is seldom cleared, an extra precaution is taken to prevent accidental clearing of this file. When the command is issued, the computer will respond with the following message:

CLEAR DRAWING FILE?

To this question, the operator should respond with Y and a carriage return to confirm the action or an N and a carriage return to abort the action. This must be done at the teleprinter. The CLEAR command performs a dual function in that it also enables the cleared file for entry of data.

NOTE: Even if the drawing file is cleared, it has been cleared only in the temporary working area on the system platter. The file on the user platter remains the same as when the operator started work on this file. The file on the user platter changes only when the NEW command is executed.

The next two commands in the drawing and scratch file are STORE AND CLEAR and RECALL. Both of these commands cause data to be transferred between the symbol file and the drawing or scratch file. STORE AND CLEAR is used after a drawing has been generated in one of these two files and the operator wishes to store it as a symbol in the symbol file. This command also performs the CLEAR function as described ealier. RECALL, on the other hand, is used when the operator wishes to recall a symbol into the drawing or scratch file for modification. The new symbol data are then appended to whatever is currently in the file. This command also performs the function of enabling the file to accept further data.

The LIST command which is common to all three files is used mainly by the programmer for troubleshooting. This command will cause the computer to list the contents of the file on the teleprinter. Since listings may be long, they can be aborted at any time by typing a CTRL D on the teleprinter's keyboard.

4.2.2 Editing Modes

The menu includes three editing modes which makes it possible for the operator to correct erroneous inputs. All editing is done by pointing at features in the drawing. The computer searches for these features with a tolerance set from the menu. The first mode labeled "Delete", is employed when the operator wishes to erase drawing elements previously entered. In all, there are five different commands associated with this mode. These commands, LINE, TEXT, SYMBOL, CIRCLE, and ARC, must be digitized before their geometric counterparts can beliminated from a drawing file via sketch editing.

The mode labeled "Modify" includes the same commands found in the Delete mode. However, this mode gives the operator the power to modify previously entered graphics, text, and symbols without having to delete the previously entered data. Through the use of this command, the operator can change the rotation, size, and other characteristics of a given drawing element quickly and effortlessly.

The "Move" mode, enables the operator to reposition material on the drawing. Commands in this mode are POINT-ON-LINE, TEXT, SYMBOL, MOVE ALL POINTS, and TRAP MOVE. By using these modes, the operator does not have to first delete the material. An additional mode in the move column, TRAP DELETE, is used to delete entire areas of the drawing regardless of its content.

The EXIT box in the editing modes category is selected when the operator wishes to switch out of the editing modes. This box, which extends across the bottom of the mode columns, represents a most important command, for if it is not digitized upon completion of editing, the system will remain in an editing state. This command need not be given, however, when switching from one editing mode to another.

4.2.3 Keyboard

The men's keyboard serves the same basic purpose as the keyboard on the display terminal, namely, to provide a source for text and various callout entries. Incorporated into the menu to permit alphanumeric inputs without disturbing the digitizing process, this keyboard contains a full complement of standard typewriter characters, as well as three function commands and a carriage return.

The three function commands referred to are VARIABLE TEXT, DELETE CHARAC_ter, and DELETE LINE. The VARIABLE TEXT command is employed when creating symbols.

DELETE CHARACTER is a special command that allows the operator to delete a character right after it has been entered. This function is identical to the RUBOUT command on the CRT terminal and TTY keyboard. Since a large percentage of textual errors are detected just after entry, this command was

made a keyboard function. This rationale was also the basis for including DELETE LINE in the menu's keyboard. Often, an operator will see an error or decide not to use a line of text while entering it. By digitizing the DELETE LINE box, the operator tells the system to automatically remove everything in the line being constructed.

CARRIAGE RETURN is identical in function to its typewriter counterpart. It is digitized when the operator wishes to record the line just completed.

It should be noted that all entries at the keyboard are not officially entered until the carriage return is depressed. This is a signal for the computer to act upon the characters just entered. Prior to the carriage return, data are temporarily stored in the computer and can be easily aborted by using DELETE CHARACTER to erase single characters or DELETE LINE to erase an entire character string.

4.2.4 Operation Functions

The Operation Functions set the ground rules for drawing construction. For this reason, it is imperative that the operator have a thorough understanding of this menu category, for without a sound knowledge of these commands, the generation of a drawing cannot be even started. Basically, the Operation Functions category is comprised of various coordinate manipulation constants, graphic modes, and text positioning instructions. The different commands included in this category are described below.

SUBFILES - The software includes subfiles which can be used to segregate a drawing into layers or levels (similar to overlays). Subfiles can be employed as desired for any particular drawing, and there is no restriction as to subfile classification. Access to all of the subfiles at once is possible if the operator digitizes the ALL COMMAND box, which is located to the right of the last subfile on the menu.

ERASE SCREEN - The ERASE SCREEN command is used to eliminate all of the material on the display terminal's creeen. The erased materials is not destroyed, however, and can be recalled by digitizing the appropriate ACTIVATE AND DISPLAY box under File Control.

LINE TYPE - The line type can be selected through the menu for plotting. The only available line type is solid.

TEXT JUSTIFICATION - These commands direct how text is to be drawin with respect to its location. Vertical justification, which includes the commands TEXT ABOVE, TEXT ON, and TEXT BELOW, makes possible the placement of alphanumerics above, on, or below previously entered graphic constructs, such as a line.

STRM DIST - This command allows one to enter a delta value (inches) which determines how smooth the recording would be in the STREAM DIGITIZING MODE. (The user should select .001 for best results)

SELECT CHARACTER HEIGHT - This command allows the operator to enter the size (inches) of characters to be generated for text and other alphanumerics. The actual entry of a size is made at either the menu's keyboard, at the keyboard on the display terminal, or on the teleprinter.

ROUNDNESS CONTROL - This command allows the operator to control the degree of roundness displayed on the CRT while in the ARC mode. The roundness selected has no effect on the finished drawing however. After the menu hit for this item the system will type out

NO. PTS =

The user will then type in a number from 4 through 999 with the higher numbers generating smoother arcs.

GRAPHIC MODES - The items in the fifth row of the Drawing Functions category, although not spelled out as such, are graphic mode commands. These items, described below, form the basis for much of the graphic information relayed to the computer, and as a result, are used often. The operator is free to select a given graphic mode command at any time during digitizing and can do so directly. For repeatable tasks, such as constructing a series of circles, the operator needs to digitize the CIRCLE command box only once, just before he enters the first circle. This is possible because the graphic mode commands, like the text justification commands mentioned in the previous paragraph, stay in effect until the operator makes a change.

The following are graphic mode commands that can be selected from the menu:

(1) LINE - This command is employed when the object is to construct a line or series of connected lines. Lines are produced by digitizing the end points of the line segments.

(2) CIRCLE - This command governs circle generation. The operator merely digitizes the center and the circumference of the circle. (The center represents a beginning point and the point on the circumference represents an end point.)

(3) ARC CW or ACR CCW - These two commands relate to the creation of clockwise - and counterclockwise-directed arcs. Generation requires digitizing the beginning, center, and end point of the arc. (Beginning and end points for clockwise arcs are opposite from those for counterclockwise arcs.)

(4) STRM DIG (Stream Digitizing) - This command is digitized when a wavy curve, e.g., sine curve, etc., is to be produced. Since such curves may or may not be symmetrical, the operator must trace the curve on the sketch with the cursor, but is is unnecessary to digitize a multitude of points; all that is required is the recording of the beginning and end points of the curve. All interim points are automatically recorded by the system.

SYMBOL AND TEXT ROTATION (CCW) - This set of commands is used if it is desired to place symbols or text at different orientations on the drawing. Eight standard angles, from 0 degrees to 315 degrees, may be selected. If a nonstandard angle is desired, the operator would digitize MANUAL and enter the value of the angle through the menu's keyboard, through the keyboard on the display terminal, or on the teleprinter.

SCALE SYMBOL - Allows the operator to draw symbohs at an arbitrary scale.

CHARACTER DISPLAY ON/OFF - Allows one to display the drawing without text if desired, for a faster or uncluttered display.

GRID ROUNDOFF - This command establishes the value to which scaled X,Y coordinates will be rounded off during digitizing. It should be noted that the value selected pertains only to the final drawing. For example, if the sketch is 2.5 times size and has grid lines which are spaced at intervals of 0.125 inch, then the roundoff value for the final drawing would be 0.050 inch.

Seven standard grid roundoff values, from 0.025 to 0.250 inch, may be selected from the menu. If a nonstandard value is desired, the operator would digitize the MANUAL box and enter the value through the keyboard on the menu or the keyboard on the display terminal.

SET DRAWING ORIGIN - This coordinate-manipulation command is employed to make the origin of the sketch different from that of the digitizer. It is the first menu command given when digitizing a new sketch. (The origin should be selected such that the drawing data falls within the first quadrant.)

ALIGN AND SCALE DRAWING - Another coordinate-manipulation command, ALIGN AND SCALE DRAWING, directs the computer to mathematically align the sketch if it is not placed squarely on the digitizer's board. This command also tells the computer to scale the X and Y axis of the sketch independently, while making provisions for possible paper stretch or shrinkage.

SET WINDOW - The SET WINDOW command permits the operator to view any section of the final drawing on the display terminal. It is used primarily to obtain close-ups of those sections which contain an abundance of hard-to-see lines and symbols. The area to be included in the enlargement is defined by digitizing its perimeter on the sketch.

4.2.5 Lineweight

These boxes select the line weight (mils) of the particular feature being digitized. The feature must be digitized along its central axis to effect the desired feature thickness. Note that the thickness of the feature is not displayed on the CRT terminal since the line-weight data is used only during the lineal to raster conversion and subsequent plot.

Whenever a feature is too cumbersome to be digitized in the above manner, it can be "traced" as an area with the selection of line weight field 4Ø (ENCLOSED).

4.2.6 Area Type

These boxes select the area type of the digitized closed area. The available area types are as follows:

- o BLANK
- o SOLID
- o 200 LPI, 45% HALF TONE
- o 120 LPI, 17% HALF TONE

Each of the above area types will effect its function (blank-out, darken or screen) within any digitized area which has had one of the appropriate menu boxes selected. Note that a border (the digitized area) will not be produced. If such a border is desired, the area must be digitized again and one of the line weight menu boxes selected (two separate features have now been digitized).

4.2.7 Lineweight/Area Type Hierarchy

Whenever digitizing a graphic with the menu boxes "LINEWEIGHT" and "AREA TYPE" the hierarchy for those boxes must be realized. When the lineal data is converted to raster data (by the LINEAL TO RASTER CONVERSION) the following hierarchy is true.

- √ LINEWEIGHT (highest)
- √ BLANK AREA
- √ SOLID AREA
- √ 120 LPI, 17% HALF TONE
- √ 200 LPI, 45% HALF TONE (lowest)

A feature digitized with any of the "LINEWEIGHT" menu boxes (1-4Ø) will overlay all digitized area types. If these "LINEWEIGHT" features overlap each other, they will be reproduced as intended. Note that a feature digitized with menu box 40 (ENCLOSED) will produce an area but due to its hierarchy will overlay any area type.

Any area digitized with the menu box "BLANK", will overlay only the area types SOLID and the two (2) HALF TONES. However, if a BLANK area is within one of the other area types and a "LINEWEIGHT" feature type traverses through the BLANK area, the LINEWEIGHT feature type will overlay the BLANK area.

Any area digitized with the menu box "SOLID", will overlay only the two (2) HALF TONES. The LINEWEIGHT feature and BLANK areas are the only feature/area which will overlay a SOLID area.

Any area digitized with either of the two (2) HALF TONES will be overlayed by LINEWEIGHT, BLANK and SOLID feature/area types. If the two half tones overlap each other, one will superimpose on the other. This will result in a "Meshing" of the two area resulting in a darker screen.

4.2.8 Symbols

The sixth menu category, labeled "Symbols", consists of 200 blank boxes that are to be used by the operator for storing drawing symbols unique to his application. Such symbols can be basic or can contain a number of basic symbols combined into one large symbol.

SECTION 5

FLIP SYMBOL LIBRARY

5.1 General

The symbols which have been identified and assessed are those specified in the document "TYPE AND SYMBOL CATALOG for FLIGHT INFORMATION PUBLICATIONS AND ASSOCIATED PRODUCTS", Third Edition (March 1974). This document includes both the ENROUTE and TERMINAL symbols list. Although the current effort addressed itself to the TERMINAL symbols, the resulting FLIP Raster Processing System has the capability to digitize and plot (with transformation) all of the symbols in the catalog.

Many of the symbols require minimum effort to digitize. These include such symbols as circles, facility boxes, terminal information and others. Symbols such as town pattern are much more cumbersome to digitize since each square within the town border must be digitized separately since no software to execute a repetition of the square exists. Such software is supplied by Bendix, but was not procured at the option of the government.

5.2 Symbol Library at DMAAC

The symbol library at DMAAC has been generated via the Bendix System 101 The procedure used to accomplish the task is that specified in the Bendix System 101 operator manual. The only deviation from the operators instructions is the use of the LINEWEIGHT and AREA menu boxes (See Section 4).

Figure No. 5-1 through 5-31 are the symbols which exist in the system as of this writing. The figures were output on the CRT terminal and therefore do not show area fill-in. Such fill-in is obtained through the lineal to raster module.

5.3 Text Library at DMAAC

The text handling capability has been achieved via a special symbol file. This file has been digitized as a normal symbol file but is accessed only

when text is referenced by the users drawing file. Figure No. 5-26 through 5-31 show the text characters which have been digitized. Note that only solid area characters are available. Screened characters can be accommodated at a later date with appropriate changes to the lineal to raster conversion module. Any size character can be selected by simply requesting the appropriate height when the drawing file is digitized.

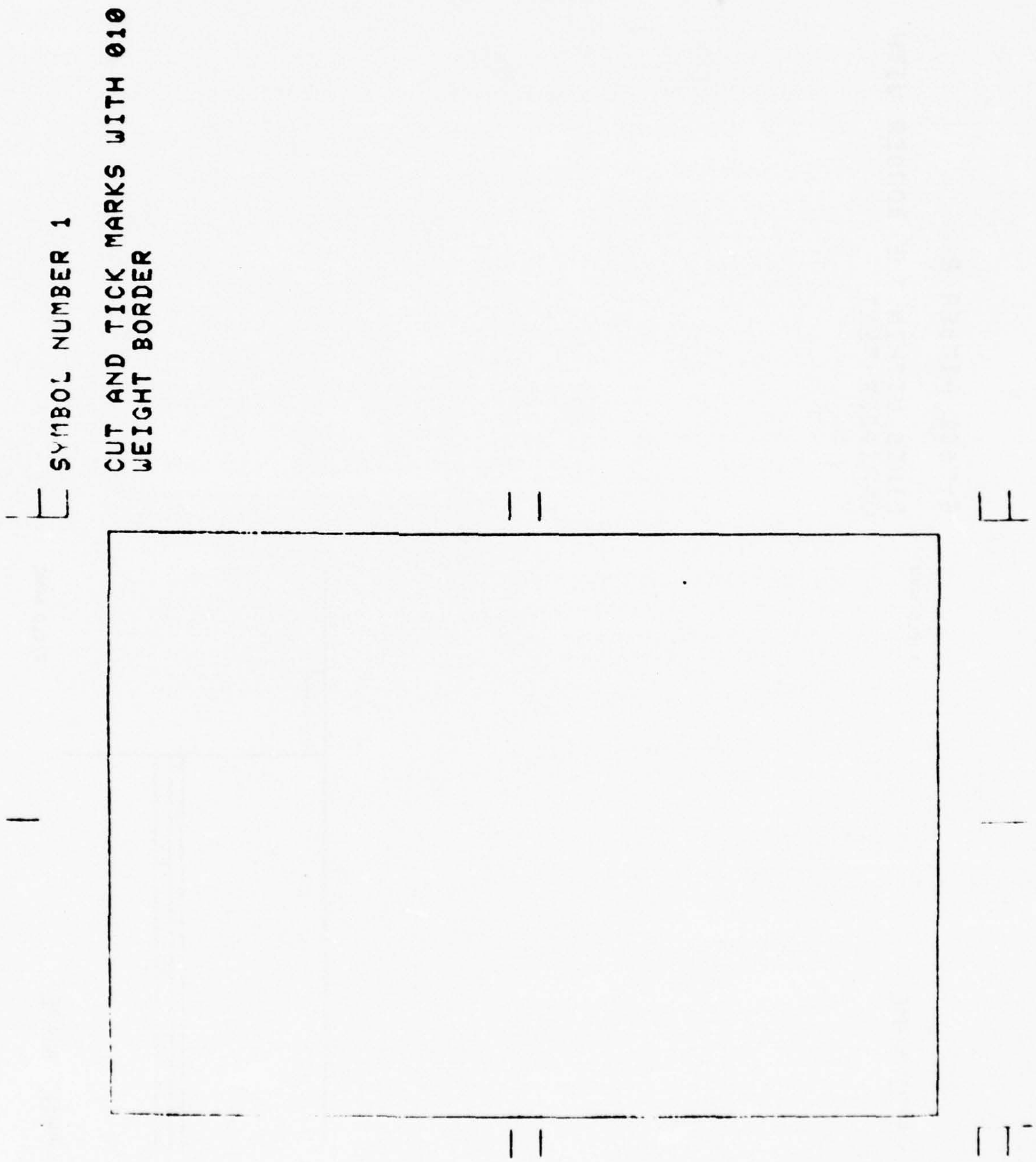


Figure No. 5-1

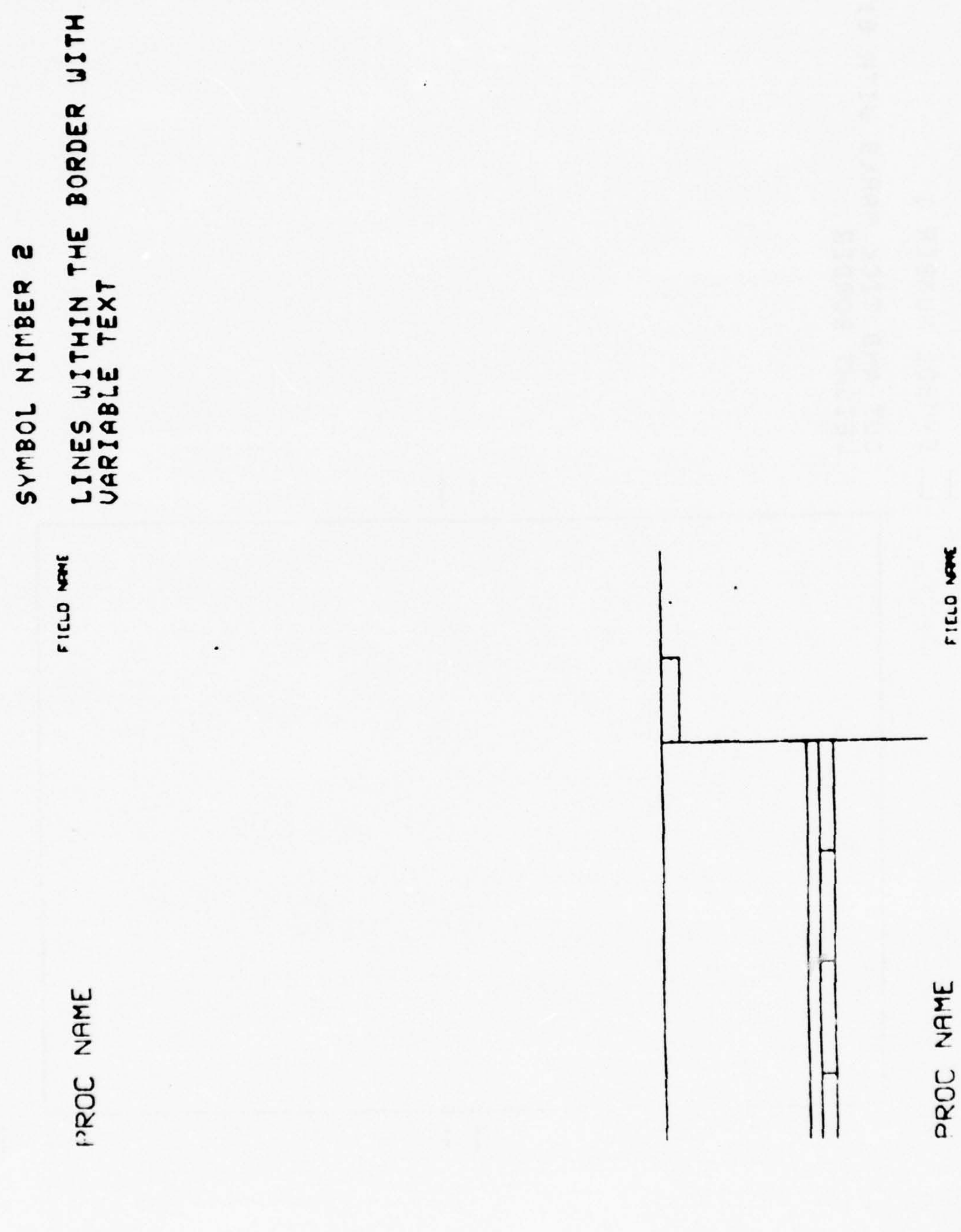

SYMBOL NIMBER 2
LINES WITHIN THE BORDER WITH
VARIABLE TEXT
FIELD NAME
PROC NAME
FIELD NAME
PROC NAME

Figure No. 5-2

SYMBOL NUMBER 3

HOLDING PATTERN BOX

Figure No. 5-3

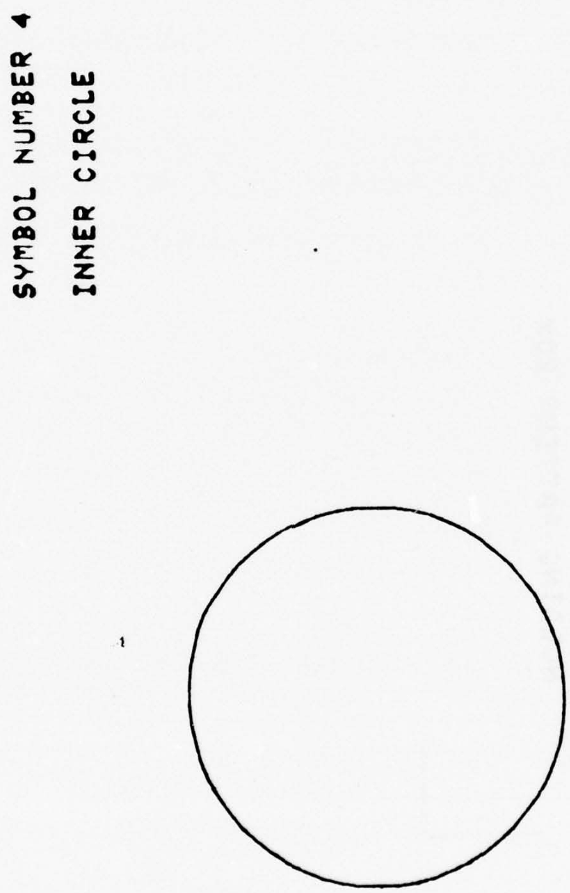


Figure No. 5-4

SYMBOL NUMBER 5

MIDDLE CIRCLE

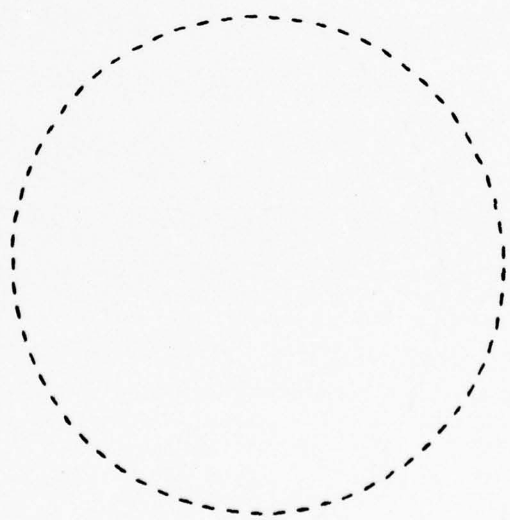


Figure No. 5-5

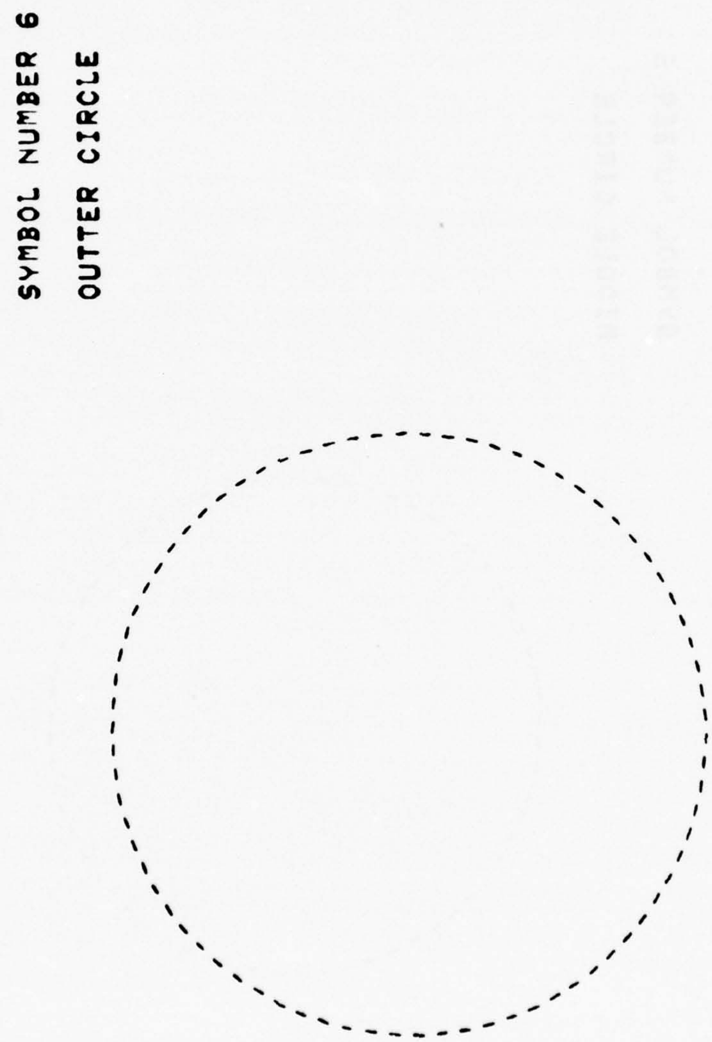
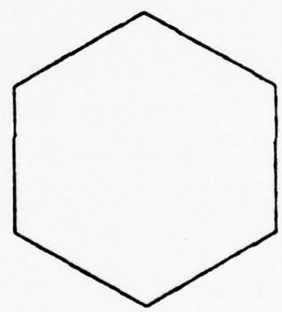


Figure No. 5-6



SYMBOL NUMBER 7
VOR

Figure No. 5-7

SYMBOL NUMBERM 8

TACAN

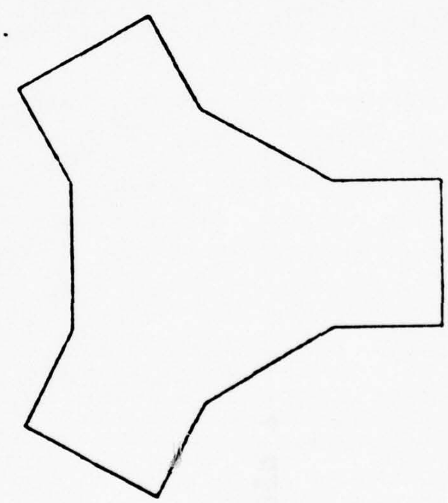


Figure No. 5-8

SYMBOL NUMBER 9

VORTAC

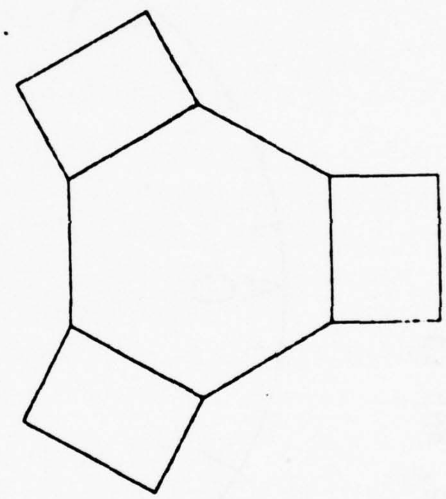


Figure No. 5-9

SYMBOLS 10, 11, 12, AND 13

COMPASS ROSE

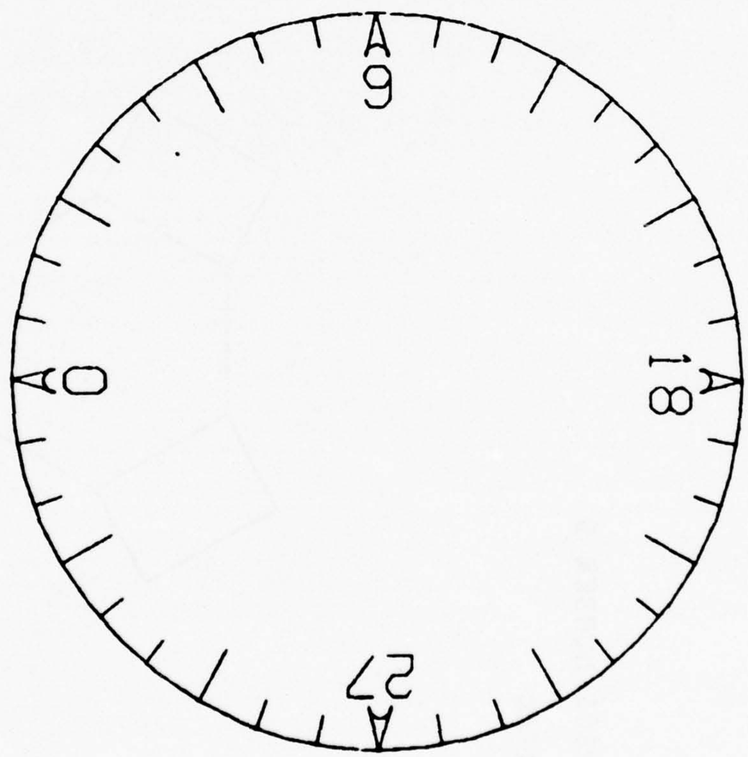


Figure No. 5-10

SYMBOLS 14 AND 15

NDB

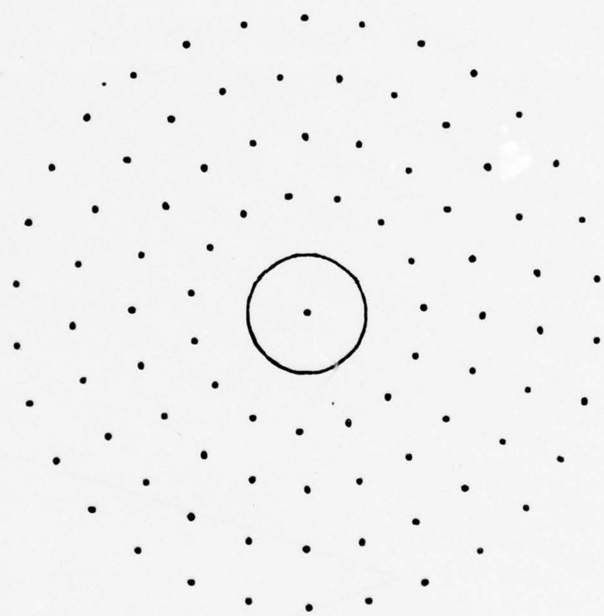


Figure No. 5-11

SYMBOL NUMBER 16

UNLIGHTED SINGLE OBSTRUCTION

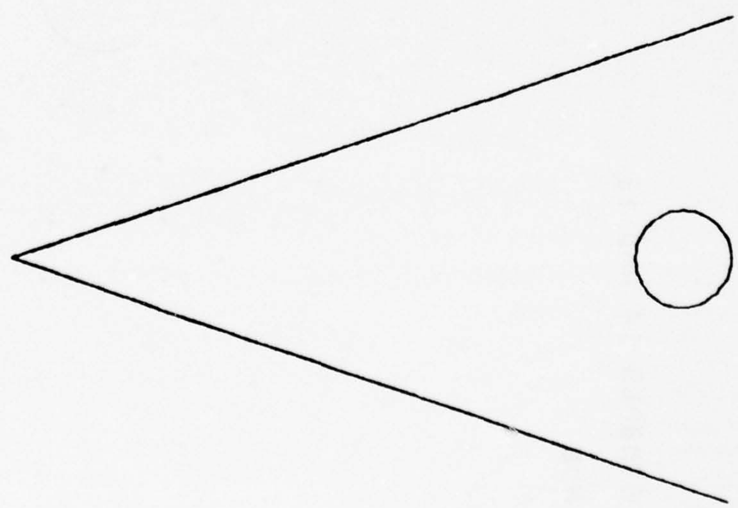


Figure No. 5-12

SYMBOL NUMBER 17

LIGHTED SINGLE OBSTRUCTION

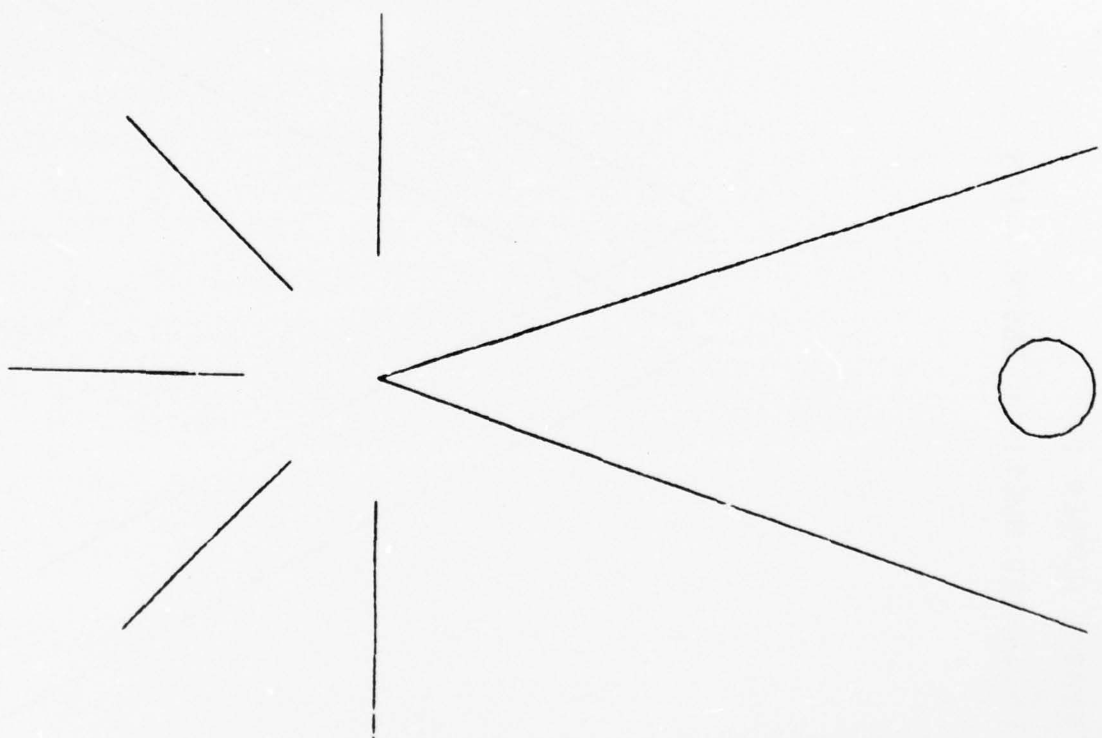


Figure No. 5-13

SYMBOL NUMBER 18

UNLIGHTED MULTIPLE OBSTRUCTION

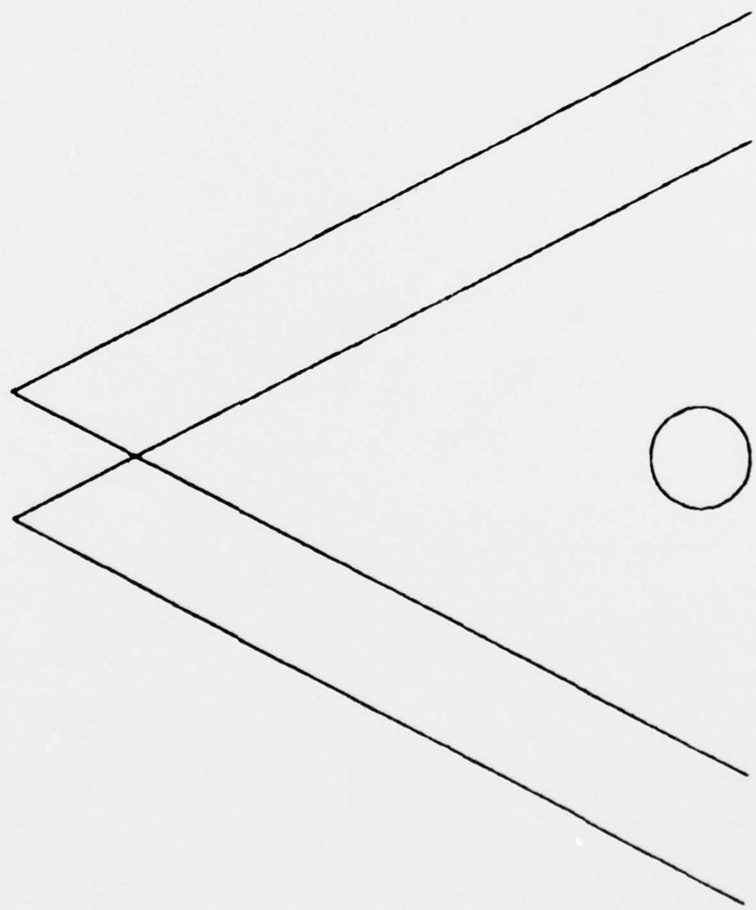


Figure No. 5-14

SYMBOL NUMBER 19

LIGHTED MULTIPLE OBSTRUCTION

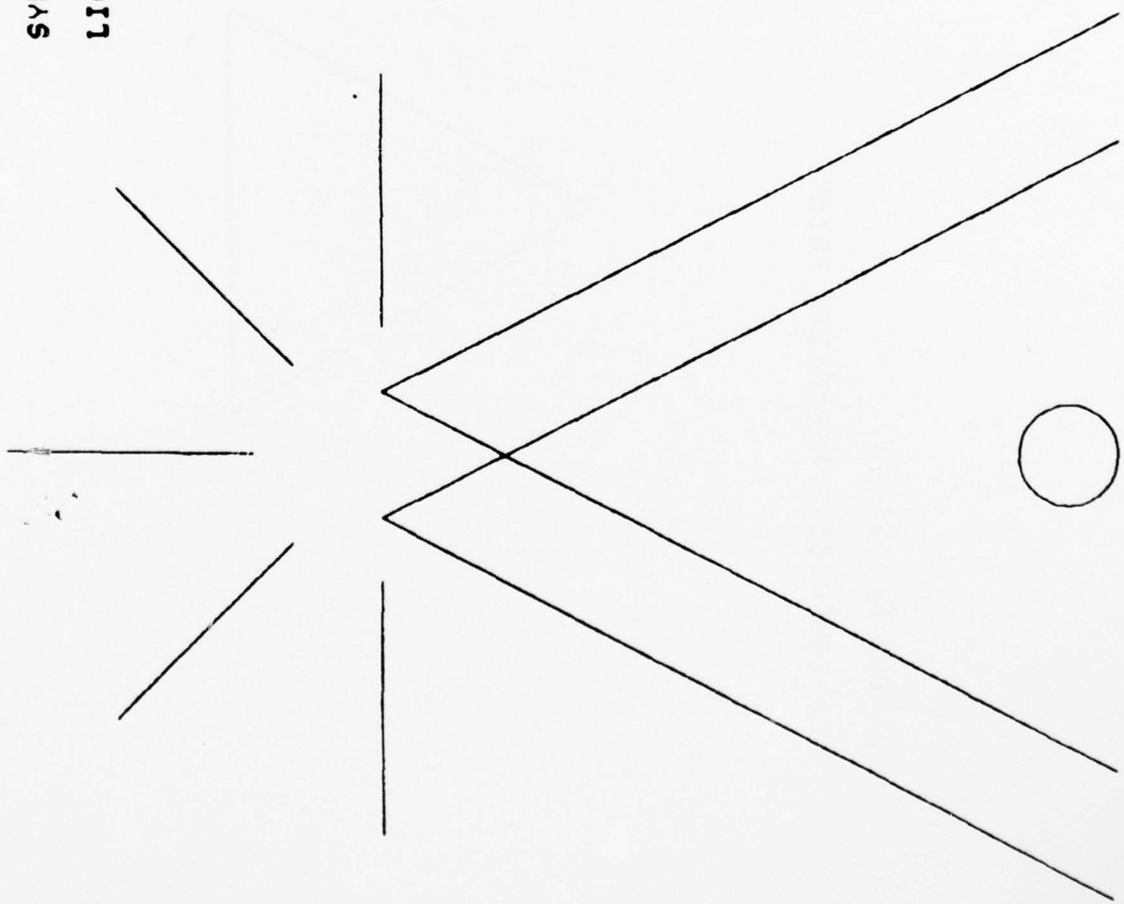


Figure No. 5-15

SYMBOL NUMBER 20

NON-COMPULSORY REPORTING POINT

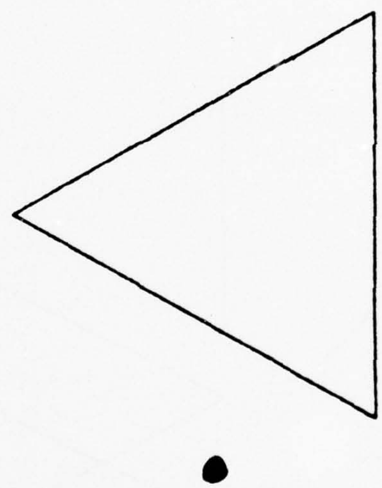


Figure No. 5-16

SYMBOL NUMBER 21

COMPULSORY REPORTING POINT

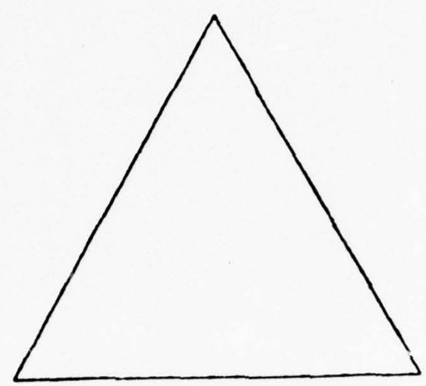


Figure No. 5-17

SYMBOL NUMBER 22

PROCEDURE TURN BARB

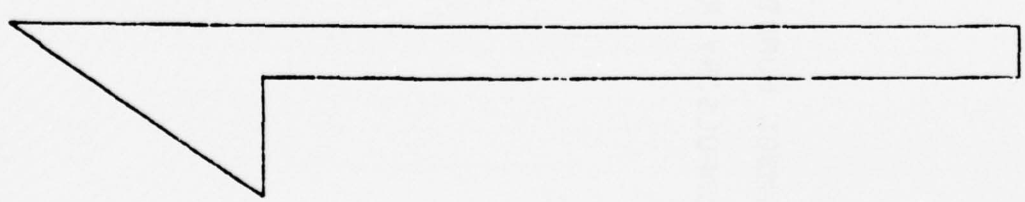


Figure No. 5-18

SYMBOL NUMBER 23

SOLID 035 DOT

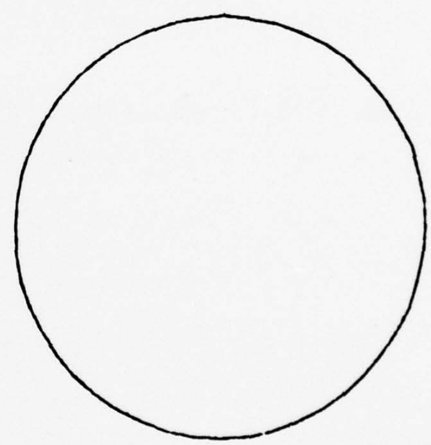


Figure No. 5-19

SYMBOL NUMBER 24

SOLID HOLDING PATTERN

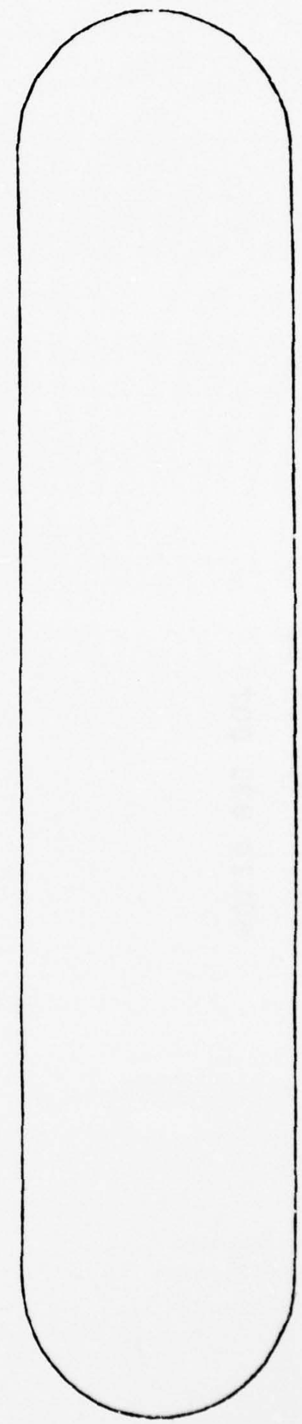


Figure No. 5-20

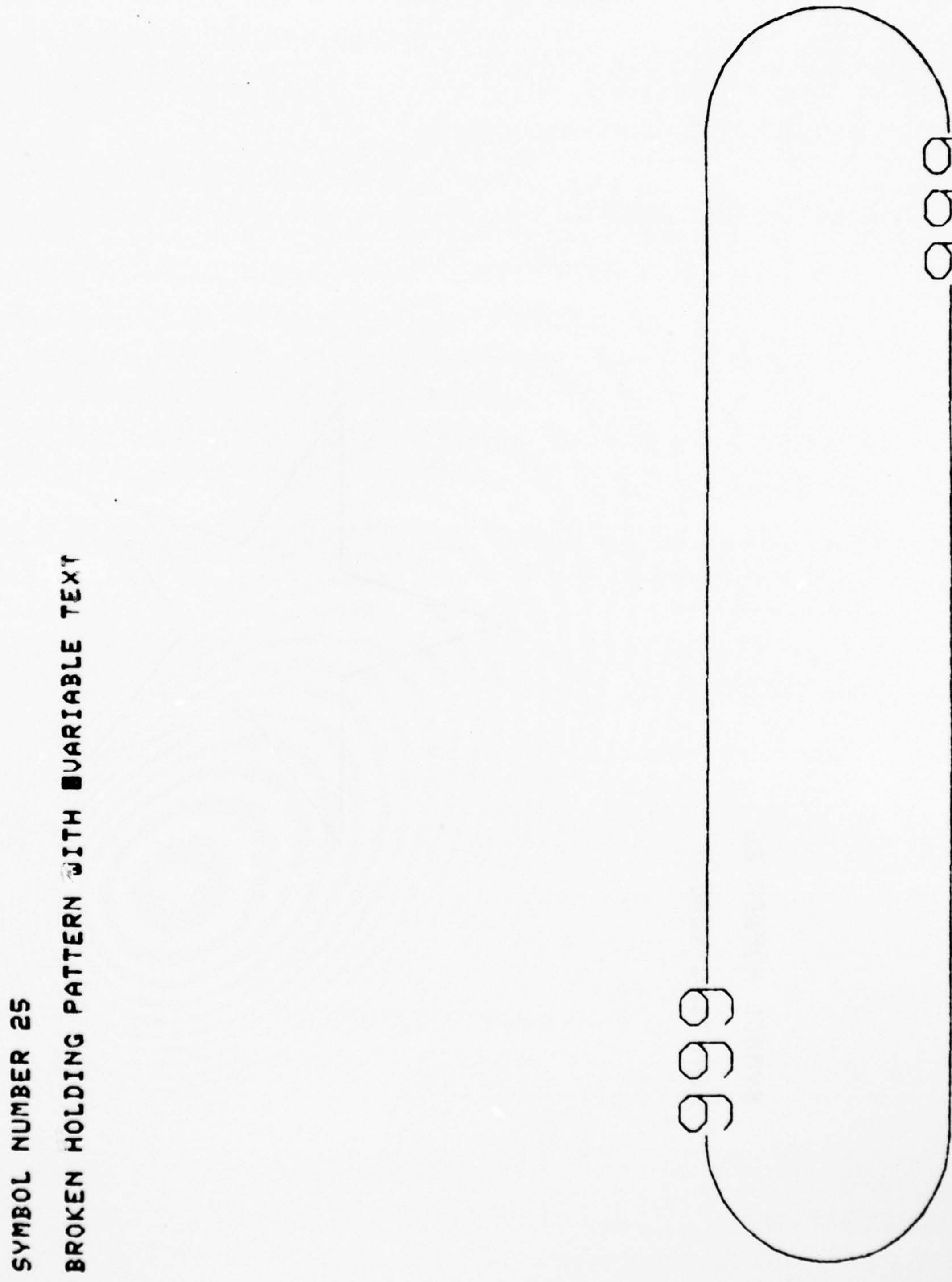


Figure No. 5-21

SYMBOL NUMBER 26

ROTATING BEACON

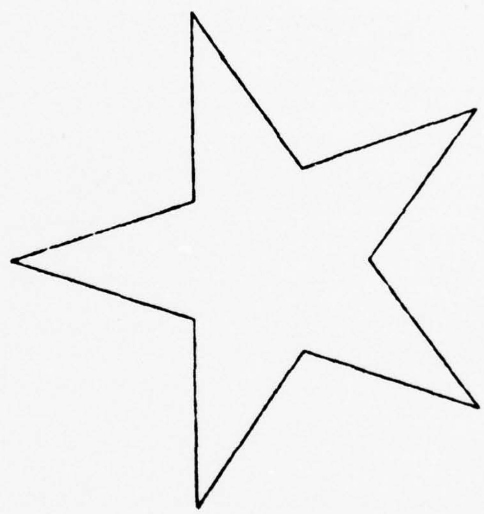
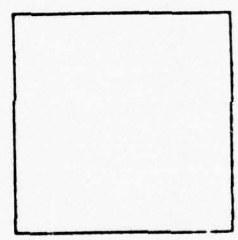


Figure No 5-22



SYMBOL NUMBER 27
CONTROL TOWER

Figure No. 5-23

SYMBOL NUMBER 28

OTHER THAN STANDARD ALTERNATE MINIMUMS

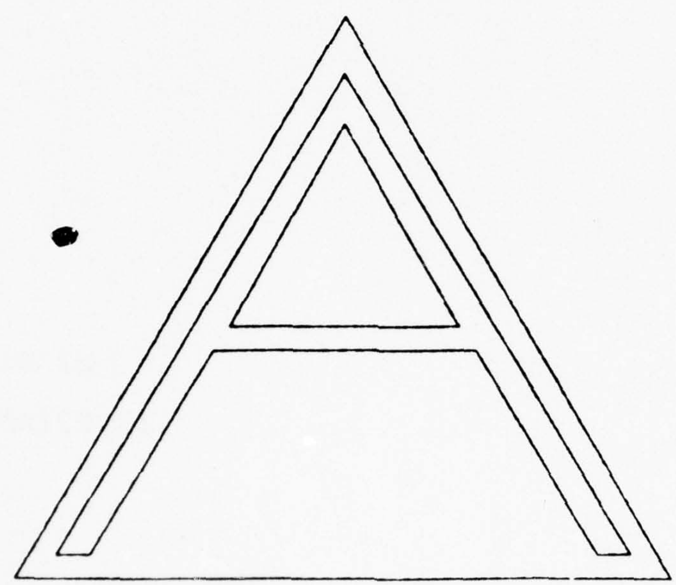


Figure No. 5-24

SYMBOL NUMBER 29

OTHER THAN STANDSRD TAKE-OFF MINIMUMS

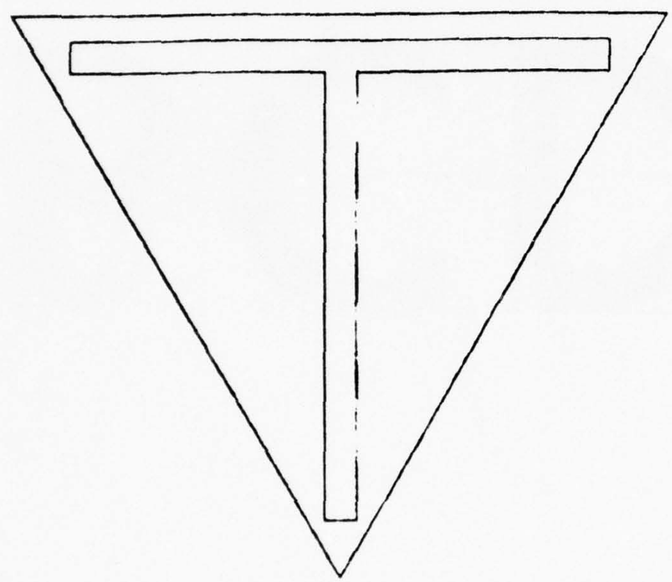
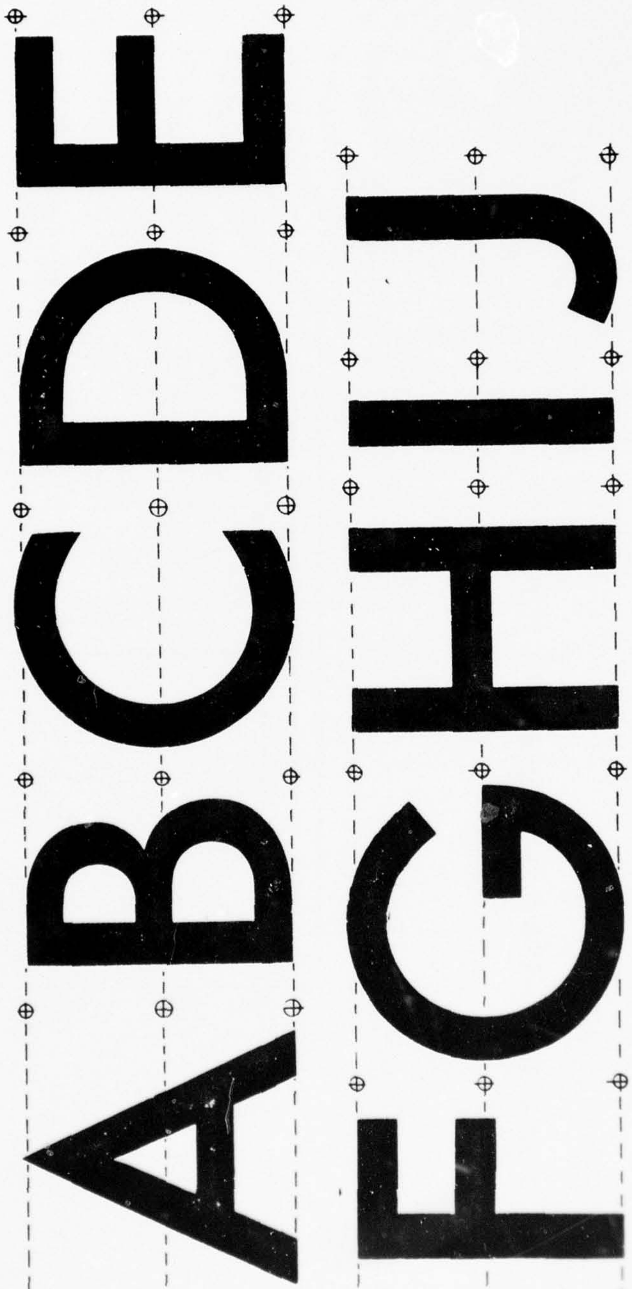


Figure No. 5-25



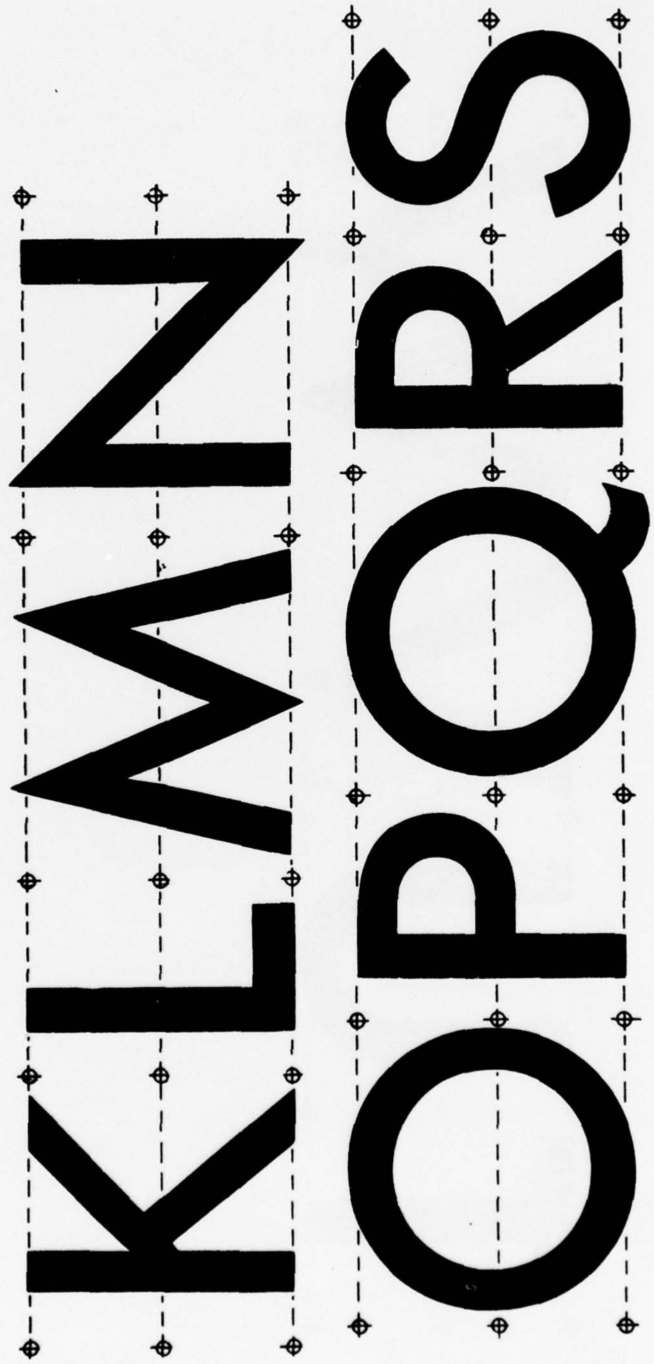
TEXT SYMBOLS

Figure No. 5-26

AD-A038 652 SYNECTICS CORP ROME N Y F/G 9/2
FLIP RASTER PROCESSING SOFTWARE SYSTEM.(U)
MAR 77 A DIPASQUA, A V LAZZARA F30602-76-C-0059
UNCLASSIFIED 723-C-2 RADC-TR-76-383 NL

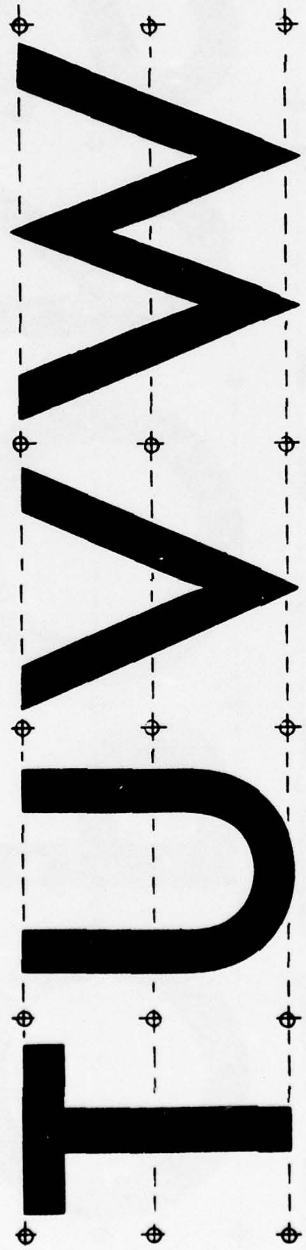
2 OF 2
AD
A038652

END
DATE
FILMED
5-77



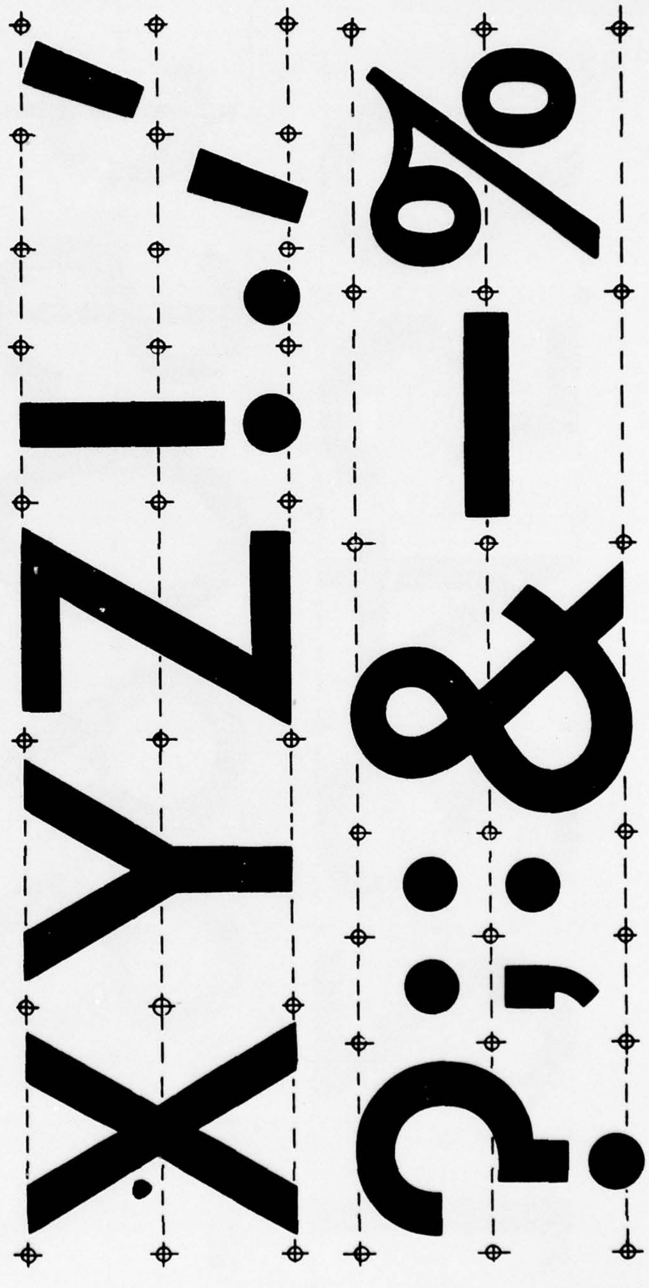
TEXT SYMBOLS

Figure No. 5-27



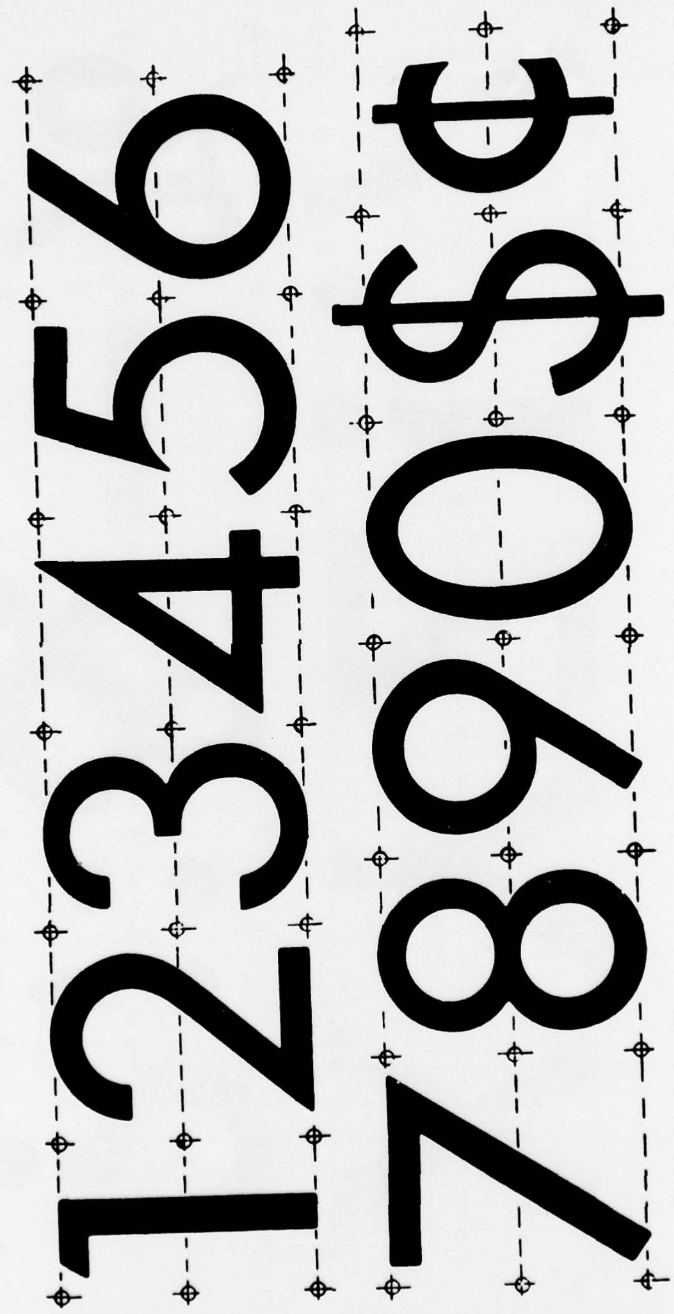
TEXT SYMBOLS

Figure No. 5-28



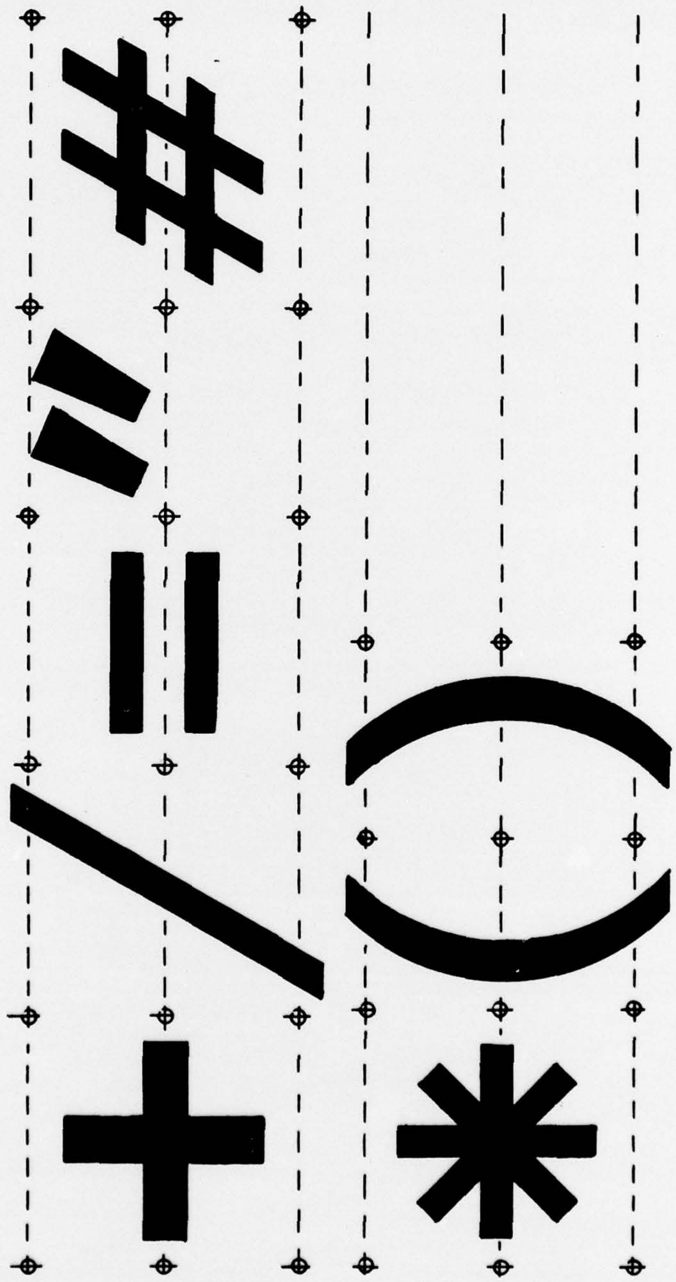
TEXT SYMBOLS

Figure No. 5-29



TEXT SYMBOLS

Figure No. 5-30



TEXT SYMBOLS

Figure No. 5-31

SECTION 6

DACOM K661A PLOTTER

SUPPORTING SOFTWARE

6.1 General

The DACOM K661A Plotter supporting software consists of a diagnostic module and a controller module. The diagnostic module allows the user to troubleshoot the plotter and interface malfunctions. The controller module allows the user to plot (record on film) magtape raster data files produced by the lineal to raster conversion module.

6.2 Plotter Diagnostic

The plotter diagnostic module consists of tests which are selected by the user to diagnose malfunctions in the plotter/interface functions. The available tests are as follows:

- ✓ PLOT BUSY TEST
- ✓ STEP BUSY TEST
- ✓ FILM LOAD TEST
- ✓ DRUM RUN TEST
- ✓ DRUM STOP TEST
- ✓ APERTURE SELECT VERIFICATION
- ✓ DATA LATE TEST
- ✓ CARRIAGE STEPPING TEST
- ✓ ONLINE/OFFLINE VERIFICATION
- ✓ PARALLEL LINES GRAPHIC VERIFICATION

Each test is selected by entering a test number when the user has been prompted by the program. A list of available tests can be printed if requested. The following subsections present a short description of the tests as implemented. All tests are interactive such that no special knowledge of commands are required.

6.2.1 Busy Tests

The busy test checks to make sure both the plot and step functions place the interface in the busy mode.

6.2.2 Film Loaded Test

The film loaded test checks whether the film loaded switch on the plotter has been activated or deactivated.

6.2.3 Drum Rotation Test

The drum rotation test ensures that the drum/run command forces the drum rotation to begin and achieve the nominal speed of 3600 RPM. It than makes sure that the drum stop command forces the drum to stop rotating.

6.2.4 Aperture Select Test

The aperture select test is a verification test for each of the available apertures (1000 LPI, 800 LPI, 600 LPI, 500 LPI, 400 LPI). Each aperture is selected and the user is prompted to verify the selection by ensuring that the aperture selection indicators are on.

6.2.5 Data Late Test

The data late test is available only for Run Length Coded data since Serial Bit Stream data cannot cause a data late. (Data late simply means that the interface was requesting data from the computer at a rate such that the computer could not supply the data.) The test makes sure this status can be achieved by forcing a worst case condition. The above mentioned data types are described in section 3.

6.2.6 Carriage Step Test

The carriage step test commands the carriage to step to the right (the only direction implemented) until the reset condition is achieved. This ensures that the light source housing can traverse the length of the carriage.

6.2.7 Online/Offline Test

The online/offline test is a verification method for the online/offline status of the plotter. This status is verified by the appropriate indicator on the plotter.

6.2.8 Parallel Lines Test

The parallel lines test is the only test requiring that the film be loaded on the plotter. The test plots scan lines such that the output graphic is a set of parallel lines. The lines are of varying thicknesses from 5 mils to 125 mils. The resulting graphic proves whether the light source is being turned on or off properly. Each line should be parallel to all the others without any waviness.

6.3 Plotter Controller

The plotter controller module is the vehicle for recording raster data from the lineal to raster conversion module onto film. Although only Serial Bit Stream (SBS) data mode has been implemented, the controller is capable of plotting Run Length Code (RLC) data. Detailed information on the data formats is available in the "K661A/NOVA interface Maintenance Manual" and the "FLIP Raster S/W Processing System Programmers Manual".

The controller consists of programs which transfer data directly from magtape to the plotter. Multiple plots along the carriage has been implemented by allowing the user to selectively plot along the carriage. The module is interactive, therefore, no special knowledge of commands is required. The controller executes in three cycles: initialization, plot, report. Each is described below.

6.3.1 Initialization Cycle

The initialization cycle includes the following:

- √ READY PLOTTER & MAGTAPE
- √ OPTIONAL MAGTAPE REWIND
- √ CARRIAGE POSITION (ORIGIN) SELECTION
- √ MAGTAPE FILE NUMBER SELECTION & POSITIONING
- √ APERTURE SIZE SELECTION

During the query sequence, erroneous inputs are monitored and retrys are executed whenever such occurs. The capability to abort is also included.

6.3.2 Plotting Cycle

Once the plotter is setup, the plotter goes online and recording commences. The technique used is a double buffering scheme. While one buffer is being filled with data from the magtape, the alternate buffer is sent to the plotter. When the first data buffer is filled, the plotter status is monitored and any errors are reported or corrected via user prompting on the active terminal. Each magtape read function is also monitored for errors and recovery procedures instituted where applicable. The above scheme is repeated by changing the buffer pointers such that the first becomes the alternate and the alternate becomes the first.

6.3.3 Report Cycle

When there is no more data from magtape, a set of statistics is printed and the user is given the option to plot again or conclude the session. If the former option is selected, the state of the plotter and magtape is left as it was at the completion of recording (except the plotter goes offline) and the next raster file may be plotted.

SECTION 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 General

This final section of the technical report addresses each of the tasks presented. Conclusions and recommendations are delineated for each task from the standpoint of analysis and experience with the subject system.

7.2 Tektronix 4014-1 Installation

The Tektronix 4014-1 is a superior CRT display terminal as compared to the original installed 4010. Figure 2-2 has shown this superiority in chart form. Even though the enhanced graphics has not been utilized during this effort, it will allow better usage of the 4014-1 in future applications. The high speed modification kit which could not be installed could be implemented in-house. The mod bit installation is not recommended since it may cause havoc with BDOS. BDOS is rather archaic in nature and does not support sophisticated computer techniques such as interrupt driven device drivers. An example of its deficiency with the CRT display is its lack of display paging. If a display fills the screen and more data is to be output, BDOS will allow overwriting of the display. Interrupt driven systems would recognize the end of display status, stop the output and wait for the user to manually erase the screen before continuing the display output.

7.3 DACOM K661A Plotter

The DACOM K661A Plotter has proved to be a reliable recording medium. The interface which communicates between the K661A and the NOVA 1220 controls all the required raster plotting functions.

Although the drum surface is 24 in X 25 in, the loading mechanism allows for film 20 in X 24 in only. The mechanism could be altered to allow for a larger size by moving the film positioning pin. DACOM should be consulted before any such alteration. Note that the FLIP terminal charts (5 in X 8 in

approx.) generate no size problem while the FLIP enroute charts (22 in X 44 in approx.) will not fit the drum on a one to one scale. If the K661A is to be used for the latter charts, the original data should be scaled so as to fit the drum surface. Of course a better method would be to keep the scale one to one and section the chart. No sectioning software exists within the present system. Future considerations must keep this in mind.

One future alteration could be made to the K661A interface with corresponding software changes. This is the capability to slew reverse. The present configuration allows for slew forward only. One possible use of the reverse slew could be to allow the backing up of the carriage to supperimpose (layers) sections of the same chart. The present set up allows this function but in a much more cumbersome way (reset the K661A and slew forward to the appropriate carriage position).

7.4 DACOM K661A Support Software

The support software (diagnostic and controller) for the K661A have had no major obstacles. It performs the intended functions. The diagnostic module is the tool via which maintenance personnel troubleshoot plotter/interface malfunctions. The controller transfers the magtape raster data files onto the film.

The controller allows the recording of multiple graphics along the carriage only. If the terminal charts are being plotted, three (3) such charts can be recorded. This process wastes about one half the 20 in X 24 in film. Multiplicity of recording could not be accomplished along the drum circumference (in one pass) since only one magtape unit is available. To perform this multiple recording in one pass, two records from two different files must be panelled in memory before plotting. This is not feasible with only one magtape unit (the disk is out of the question due to its low data storage capacity).

Multiple recording along the drum circumference can be implemented with the existing hardware in a two pass process. That is, plot the lower half

of the film (3 charts) first and then reset the carriage to plot the upper half (3 charts). The upper half plotting requires blank fill data to be prefixed to the raster data file records. This could be accomplished during the LRC process or at plot time.

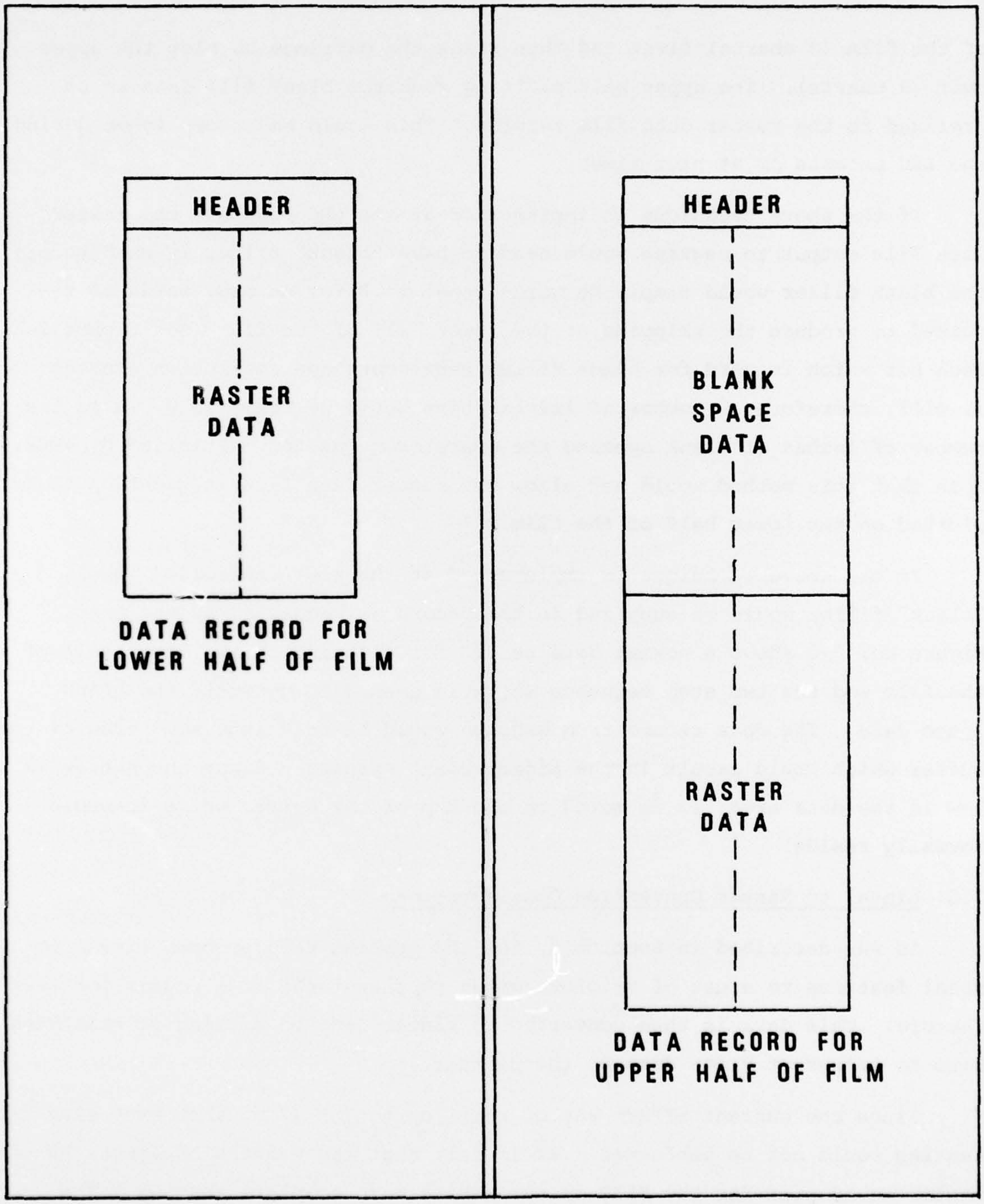
If the above technique is implemented at the LRC process, the raster data file output to magtape would need to have "blank" filler in each record. The blank filler would simply be words reset to Ø for as many words as required to produce the skipping of the lower half of the film (See Figure 7-1). Each bit which is used for blank filler represents one resolution element (1 mil), therefore, N number of initial bits would be reset to Ø. N is the number of inches of blank spacing the operator requested multiplied by 1ØØØ. Note that this method would not allow the raster data file in question to be plotted on the lower half of the film.

If the above technique is implemented at the plot controller level, "blank" filler would be supplied in the record as requested by the user. Figure No. 7-2 shows a normal data record for plotting on the lower half of the film and the two step sequence which is needed to generate the blank space data. The data record from magtape would be read into some area of the buffer which would result in the proper blank spacing. Since the header is now in the data area, it is moved to the top of the buffer where it would normally reside.

7.5 Lineal to Raster Conversion Consideration

As was described in Section 3, the LRC process reduces both lineal or areal features to a set of triplets which represent the area bounds for that feature. This data is then converted to raster data by setting or resetting bits to represent video data on the plotter.

Since the current effort was of short duraction (7 months) extensive testing could not be performed. It is felt that the process of lineal to raster as adopted for the FLIP system merits more complete testing. The types of data features being processed are varied and quantitavely large.



MULTIPLE PLOTTING DATA RECORDS
METHOD 1

Figure No. 7-1

If such a test program is instituted, complete LRC process confidence could be had by analyzing the results and making algorithm corrections where necessary. Although piecemeal film output has proven that a major portion of the LRC process is operational, no complete graphic has been processed due to the mentioned time constraints.

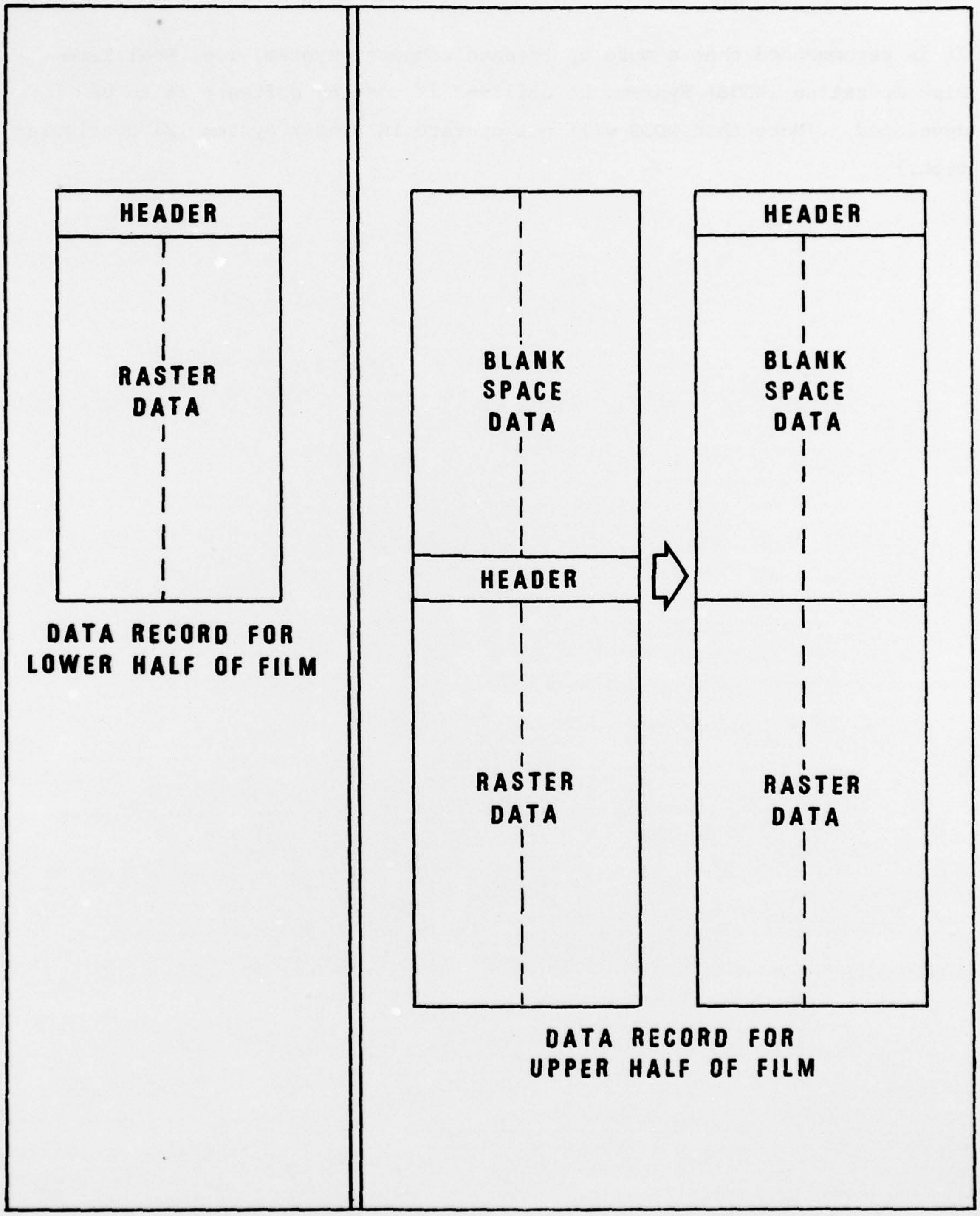
The one major drawback of the LRC process as implemented under BDOS is that it is a relatively slow process. Much of the blame must be attributed to DBOS' sequential file access method. Being the only method for accessing files, it had to be used. Implementing new software to bypass this drawback is a major effort in itself. Therefore, the merging of files has been turned into a standard magtape sort, where the disk is replacing the magtapes.

It is not recoimended that major revisions be made to the LRC software. BDOS contains other system software problems besides the above mentioned drawback. For instance, the "TYPE" and "ACCEPT" Fortran Library functions are not completely debugged and cause programs to "crash" sporadicaly. It was also found that certain software code would cause a "crash" when loaded in one memory area (loader controlled). By moving (using the editor) the code to a different physical location in the program, the software code would run without a "crash". This type of problem is unacceptable in that it results in much wasted time for implementation.

It should be noted here that the Bendix Interactive Drafting System (System 101) performs it digitization functions satisfactorily. The above comments reflect the experience had in implementing complex software under an archaic system such as BDOS. Bendix has done extensive circumventing of the problems. Their experiences have not been shared under this effort.

7.6 Major Conclusions

The one major conclusion from this effort is that the lineal to raster conversion process can be implemented on a minicomputer. The minicomputer used was the NOVA 1220-a 16 bit machine with 24K of memory. The computer presented no major drawback in developing the LRC process. The only drawback was due to the system software which supervised the user programs.



MULTIPLE PLOTTING DATA RECORDS
METHOD 2

Figure No. 7-2

It is recommended that a more up to date computer system, i.e. Real Time Disk Operating (RDOS) System, be utilized if complex software is to be developed. (Note that RDOS will not operate in Bendix System 101 configuration.)

METRIC SYSTEM

BASE UNITS:

Quantity	Unit	SI Symbol	Formula
length	metre	m	...
mass	kilogram	kg	...
time	second	s	...
electric current	ampere	A	...
thermodynamic temperature	kelvin	K	...
amount of substance	mole	mol	...
luminous intensity	candela	cd	...

SUPPLEMENTARY UNITS:

Quantity	Unit	SI Symbol	Formula
plane angle	radian	rad	...
solid angle	steradian	sr	...

DERIVED UNITS:

Quantity	Unit	SI Symbol	Formula
Acceleration	metre per second squared	...	m/s
activity (of a radioactive source)	*disintegration per second*	...	(disintegration)/s
angular acceleration	radian per second squared	...	rad/s
angular velocity	radian per second	...	rad/s
area	square metre	...	m
density	kilogram per cubic metre	...	kg/m
electric capacitance	*farad*	F	A·s/V
electrical conductance	siemens	S	A/V
electric field strength	volt per metre	...	V/m
electric inductance	henry	H	V·s/A
electric potential difference	volt	V	W/A
electric resistance	*ohm*		V/A
electromotive force	volt	V	W/A
energy	joule	J	N·m
entropy	joule per kelvin	...	J/K
force	newton	N	kg·m/s
frequency	hertz	Hz	(cycle)/s
illuminance	lux	lx	lm/m
luminance	candela per square metre	...	cd/m
luminous flux	lumen	lm	cd·sr
magnetic field strength	ampere per metre	...	A/m
magnetic flux	weber	Wb	V·s
magnetic flux density	tesla	T	Wb/m
magnetomotive force	ampere	A	...
power	watt	W	J/s
pressure	pascal	Pa	N/m
quantity of electricity	coulomb	C	A·s
quantity of heat	joule	J	N·m
radiant intensity	watt per steradian	...	W/sr
specific heat	joule per kilogram-kelvin	...	J/kg·K
stress	pascal	Pa	N/m
thermal conductivity	watt per metre-kelvin	...	W/m·K
velocity	metre per second	...	m/s
viscosity, dynamic	pascal-second	...	Pa·s
viscosity, kinematic	square metre per second	...	m/s
voltage	volt	V	W/A
volume	cubic metre	...	m
wavenumber	reciprocal metre	...	(wave)/m
work	joule	J	N·m

SI PREFIXES:

Multiplication Factors	Prefix	SI Symbol
1 000 000 000 000 = 10^{12}	tera	T
1 000 000 000 = 10^{9}	giga	G
1 000 000 = 10^{6}	mega	M
1 000 = 10^{3}	kilo	k
100 = 10^{2}	hecto*	h
10 = 10^{1}	deka*	da
0.1 = 10^{-1}	deci*	d
0.01 = 10^{-2}	centi*	c
0.001 = 10^{-3}	milli	m
0.000 001 = 10^{-6}	micro	μ
0.000 000 001 = 10^{-9}	nano	n
0.000 000 000 001 = 10^{-12}	pico	p
0.000 000 000 000 001 = 10^{-15}	femto	f
0.000 000 000 000 000 001 = 10^{-18}	atto	a

* To be avoided where possible.